PROCEEDINGS of the HAWAIIAN ENTOMOLOGICAL SOCIETY for 1952

VOL. XV, No. 1
MARCH, 1953

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Christenson, L. D.
Clagg, C. F.
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Doutt, R. L.
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French, E. W.
Gressitt, J. L.
Hagen, K. S.
Haramoto, F. H.
Hardy, D. Elmo
Himeno, Edward
Hinman, F. G.
Holdaway, F. G.
Hoyt, Charles P.
Hu, Stephen M. K.
Ito, K.
Joyce, C. R.
Kamasaki, Hitoshi
Kartman, Leo
Keck, C. B.
Keiser, Irving
Kono, Constance Inada
Krauss, N. L. H.
Kumabe, Bunki
Lepesme, Pierre
Look, Wm. C.
Macdougall, G. W.
McBride, O. C.
Maehler, K. L.
Marlowe, R. H.
Marucci, P. E.
Matsuura, M.
Messenger, P. S.
Mitchell, W. C.
Morishita, Frank R.
Mumford, E. P.
Nakagawa, Patrick Y.
Nakagawa, Susumu
Nakao, Harry
Newell, I. M.
Nihei, C. T.
Nishida, Takiyuki
Nowell, W. R.
Owen, R. P.
Pemberton, C. E.
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Randall, Helen Au
Rathburn, Francis
Ritchie, C. L.
Rosa, J. S.
Sakimura, K.
Schmidt, C. T.
Sherman, John D.
Sherman, Martin
Steiner, L. F.
Stone, W. E.
Suehiro, Amy
Tamashiro, Minuro
Tanada, Yoshinori
Thomsen, Walter
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Weber, P. W.
Wirth, W. W.
Yasuda, Charles
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Sherman, [illegible]
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Yamamoto, Robert
Zimmerman, E. C.

PROCEEDINGS

OF THE

Hawaiian Entomological Society

VOL. XV, NO. 1 FOR THE YEAR 1952 MARCH, 1953

JANUARY 14, 1952

The 553rd meeting was held at the H.S.P.A. Experiment Station on Monday, January 14, at 2:00 p.m., with President Bess in the chair.

Members present: Adachi, Bess, Bryan, Chilson, Ford, Fullaway, Haramoto, Hardy, Himeno, Hinman, Hu, Joyce, Kamasaki, Keck, Look, Messenger, Mitchell, Newell, Nishida, Pemberton, Rosa, Suehiro, Swezey, Tamashiro, Tuthill, Van Zwaluwenburg, and Zimmerman.

Visitor: Alan P. Dodd. Frank M. Morishita and Dr. Leo Kartman, the latter a former member of the Society, were nominated for membership.

NOTES AND EXHIBITIONS

ESTIGMENE ACRAEA (Drury)—Mr. Fullaway exhibited an adult of this arctiid moth, reared from a larva found in an apple box from California. The species is not established in Hawaii. Its caterpillars feed on a wide variety of hostplants.

CATORAMA HERBARIUM Gorham—Dr. Swezey reported rearing this anobiid beetle from dry cacao beans, January 9; there were eight larvae in a single bean. He added that last month Dr. H. L. Lyon had brought in seeds of *Canavalia* infested by this insect, and that in August 1945 Dr. Lyon had reared *C. herbarium* from the husk of a *Macadamia* nut.

FLEAS ON WAKE ISLAND—Mr. Chilson said that C. F. W. Muesebeck of the U. S. National Museum had reported as *Xenopsylla cheopis* (Rothschild), fleas collected May 15, 1951, in trash on a warehouse floor on Wake Island. This appears to be the first specific record of fleas on Wake.

DIRHINUS GIFFARDII Silvestri—Mr. Nishida reported that in September 162 puparia of *Dacus cucurbitae* Coquillett were collected in an abandoned watermelon field at Waimanalo, Oahu. From these 24 *Dirhinus giffardii* and one *Opius fletcheri* Silvestri emerged. This appears to be the first recovery *of D. giffardii* from the melon fly. The parasite was introduced in 1913 by Silvestri as a pupal parasite of the Mediterranean fruit fly ("PROCEEDINGS" 5:302-304, 1923[1]). The present material was identified by Mr. Fullaway.

[1] Here, and elsewhere in this publication, "PROCEEDINGS" refers to the Proceedings of the Hawaiian Entomological Society.

EUXESTUS ERITHACUS Chevrolat—Mr. Ford reported the presence here of this erotylid beetle, a new record for the Hawaiian Islands. The identification was made by W. S. Fisher from material with the following data: Kaimuki, Oahu, October 19, 1946, J. H. Nichols; Honolulu, October, 1946, P. W. Weber; Moanalua, Oahu, March, 1947, K. L. Maehler; and Waianae, Oahu, February, 1950, under rotting papaya trunk, E. J. Ford, Jr. In addition, there are specimens, all from Oahu, in the H.S.P.A. collection, the earliest taken by O. H. Swezey in May, 1915; later specimens were collected in rotten sugar cane stalks and under breadfruit bark. Until now only two other erotylids were known here: *Euxestus parki* Wollaston and *Eidoreus minutus* Sharp.

TROPISTERNUS LATERALIS var. DORSALIS Brullé—Mr. Ford reported that this hydrophilid, first taken in Honolulu in 1948 ("PROCEEDINGS," 13: 323, 341) was abundant last year in a stagnant pool near Waianae, Oahu. A specimen was brought to the H.S.P.A. for identification in November, 1951, which had been taken in a light trap at Waialua, Oahu.

FEBRUARY 11, 1952

The 554th meeting was held at the H.S.P.A. Experiment Station on Monday, February 11, at 2:00 p.m., with President Bess in the chair.

Members present: Adachi, Beardsley, Bess, Bryan, Chilson, Clagg, Dresner, Fullaway, Hardy, Hinman, Joyce, Kamasaki, Look, Maehler, Messenger, Mitchell, Morishita, Newell, Nishida, Owens, Pemberton, Roan, Martin Sherman, Smith, Steiner, Suehiro, Swezey, Tamashiro, Tuthill and Van Zwaluwenburg.

Visitors: C. P. Clausen, Alan P. Dodd, T. R. Gardner, J. L. Gressitt, O. N. Liming, A. P. Messenger, Alan Thistle and Robert Yamamoto.

Frank R. Morishita and Leo Kartman were unanimously elected members. The following were nominated for membership: J. L. Gressitt, Harry Nakao of the Board of Agriculture and Forestry, and Robert Yamamoto of the University of Hawaii.

PAPER

Alan P. Dodd read his paper: "Observations on the stem gall fly of pamakani, Eupatorium glandulosum."

NOTES AND EXHIBITIONS

AN UNCOMMON MILLIPEDE—Mr. Beardsley exhibited specimens of a millipede belonging to the family Polyxenidae. They were taken on the under surface of guava leaves in Waikakalaua gulch, Oahu; the leaves were some inches above the ground and hidden in heavy grass. Previously two members of this family were known locally: an American species, *Polyxenus fasciculatus* Say, found in soil, and *P. hawaiiensis* Silvestri, presumably native.

ISCHNASPIS LONGIROSTRIS (Signoret)—Dr. Swezey exhibited specimens of this scale on leaves of a palm, *Chrysalidocarpus lutescens*, collected in Honolulu, February 11. This appears to be a new hostplant record for the scale in Hawaii.

CERATOCOMBUS sp.—Miss Adachi exhibited a specimen of this cryptostemmatid bug recently collected near the Manoa Valley waterfall, on Oahu. Previously only one species of the genus, *C. hawaiiensis* Usinger, has been known in Hawaii, and it has been found only on Kauai.

POLISTES EXCLAMANS EXCLAMANS Viereck—Mr. Clagg reported that this recently discovered immigrant wasp has spread considerably from McGrew Point, Aiea, Oahu, where it was first found. On January 1, a male was taken in Navy Housing, Makalapa area, two miles from McGrew Point. On January 25, it was found on Moanalua ridge, three miles east of the original site, and on January 30, Harry Clagg found it in Civilian Housing Area III, some three and one-half miles south of McGrew Point.

A NEW CONIOPTERYGID—Mr. Pemberton exhibited specimens of a hitherto unknown neuropteron of the family Coniopterygidae, first taken in a light trap at Ewa Plantation, Oahu, on February 4, 1952. This is a new immigrant to the Islands.[1]

EURYTOMA ORCHIDEARUM (Westwood)—Dr. Bess exhibited stems of *Cattleya* orchids bearing galls caused by the "orchid fly." An orchid house which he recently visited had over half the plants similarly affected.

ALEUROCANTHUS SPINIFERUS (Quaintance)—It was reported by T. R. Gardner and Dr. Pemberton that this aleurodid was recently identified from material collected on Guam by George D. Peterson, Jr.; it is very destructive there.

GONAXIS KIBWEZIENSIS Smith—Mr. Owen reported on a visit he made on August 30, 1951, to the island of Agiguan in the Marianas. This is the island on which 229 *Gonaxis* snails were released on May 30, 1950. Fifteen months after its introduction, *Gonaxis* had survived and multiplied, and its prey, the giant African snail, *Achatina fulica* (Férrusac), appeared to have been considerably reduced.

MARCH 10, 1952

The 555th meeting was held at the H.S.P.A. Experiment Station on Monday, March 10, at 2:00 p.m. In the absence of both the President and Vice-President, Dr. Hardy was asked to preside.

Members present: Adachi, Chilson, Clagg, Dresner, Ford, Fullaway, Gressitt, Hardy, Hinman, Joyce, Keck, Look, Maehler, Messenger, Mitchell, Pemberton, Rosa, Suehiro, Swezey, Van Zwaluwenburg and Zimmerman.

[1] Described as *Coniopteryx pembertoni* by D. E. Kimmins, on p. 37 of this issue of the "PROCEEDINGS."

Visitors: A. J. Flebut and G. W. Macdougall. Unanimously elected to membership in the Society were J. L. Gressitt, Harry Nakao and Robert Yamamoto. G. W. Macdougall of the U. S. Bureau of Entomology and Plant Quarantine, was nominated for membership.

NOTES AND EXHIBITIONS

DOIUS MERIDIANUS Matsushita—Mr. Zimmerman exhibited two examples of this cerambycid beetle, a newly established immigrant on Oahu. The specimens were taken by W. C. Look on Alewa Heights, one on June 5, 1951, the other in August, 1951. They were identified by Dr. J. L. Gressitt who states that *Doius* is very close to *Diboma* in the tribe Estolini. The species was described from a single specimen from Formosa (Journ. Faculty Agr., Hokkaido Imp. Univ., Sapporo, 34: 380, fig., 1933), but has since been taken in the Ryukyu Islands, and may be even more widely distributed.

MACROSIPHUM GRANARIUM (Kirby)—Mr. Zimmerman reported that this English grain aphid was collected May 7, 1948 by F. A. Bianchi, at Pohakuloa, Hawaii at an elevation of 6,500 feet. This is a new island record for the species, locally recorded until now only from the highlands of Haleakala, Maui.

TACHYS LUTEUS Andrewes—Mr. Zimmerman reported collecting two examples of this small carabid beetle in Manoa Valley, Honolulu, in January, 1952. One was taken from the reflector of a reading lamp, the other was flying in the garden at dusk. This is a new immigrant to the Hawaiian Islands, known hitherto only from the unique type described from Singapore (Ann. Mus. Civ. Genova, 51: 390, 1925). The species was identified by P. J. Darlington, Jr., and was checked with the type in the British Museum by E. B. Britton.

This carabid closely resembles *Perigona nigriceps* (Dejean), another of our immigrant species. The two may be separated by the following characters: (1) on *T. luteus* the head and pronotum are concolorous, whereas in *Perigona* the nearly black head contrasts sharply with the brown pronotum; (2) the hind corners of the pronotum of *T. luteus* are square and sharp, whereas in *P. nigriceps* they are rounded. Britton's key ("PROCEEDINGS," 13: 238, 1948) to the Hawaiian species of *Tachys* should be emended as follows to include the new immigrant: At the beginning of the key insert

A. Elytra with the first six striae evident basad of middle.....**luteus** Andrewes
Elytra with not more than the first three striae evident basad..... 1

ARGIOPE APPENSA Walckenaer—Mr. Mitchell reported that on February 24 he collected this recently established spider on the Kaneohe-Kailua (Kapaa) ridge, Oahu.

HAWAIINA CALIDA (Butler)—Dr. Swezey exhibited a specimen of this rare native sphingid, captured at light on February 17 in Manoa Valley. It is the first specimen he ever saw in the lowlands, although one was captured some years ago at Waikiki. The moth probably came down from

the forest region, where the green larvae feed on a number of native plants, including *Scaevola gaudichaudiana.*

APANTELES MARGINIVENTRIS (Cresson) —Dr. Swezey reported rearing this braconid from a caterpillar of the geometrid, *Scotorythra caryopis* Meyrick, feeding on "koa" on Mt. Tantalus, Oahu. Introduced in 1942 from Texas as an enemy of armyworms, this parasite has become effective on *Laphygma exempta* (Walker) and on *Hymenia recurvalis* F. Breeding it from a native forest moth shows that it has spread into the mountains, where it will probably attack other native moths just as other introduced parasites have in recent years.

METIOCHE VITTATICOLLIS (Stål)—Mr. Fullaway reported the presence of this immigrant cricket at Lanikai, Oahu, a region from which it had not been reported before.

AMOBIA sp.[2]—Mr. Keck exhibited a *Eumenes* cell, collected last month at the Oahu Country Club, which contained 23 puparia of this recently discovered sarcophagid parasite of eumenid wasps.

HOLCOBIUS GLABRICOLLIS Sharp—Mr. Ford reported taking this native anobiid in the Waianae Mountains, Oahu, on February 17. Until now it had only been known from the Koolau range, Oahu.

TENODERA AUSTRALASIAE (Leach) —Mr. Keck reported finding, January 28, an egg case of this recent immigrant mantid at Hickam Field, Oahu. This is a considerable eastward extension of the known range of this insect, previously known on Oahu only from the Ewa district. Mr. Maehler exhibited the ootheca of what is probably this species, taken by him in February, 1952, on Guam; this is a new island record for the species. He added that a specimen of *T. australasiae,* until recently assumed to be *T. angustipennis* Saussure, was taken by E. J. Ford, Jr., at Barber's Point Naval Air Station in April, 1950. This antedates by more than a year, the first record of this mantid at Ewa ("PROCEEDINGS," 14: 364).

GUAM INSECTS—Mr. Maehler reported that *Aleurocanthus spiniferus* (Quaintance), recently established on Guam, was observed, on a recent trip to that island, to be a serious pest of citrus. In parts of the Orient this species is said to be more serious than even *A. woglumi* Ashby. Comparatively little citrus is grown on Guam. Attacking it, besides the whitefly, are a buprestid twig borer, *Agrilus occipitalis* (Eschscholtz), a leafmining lepidopteron, *Phyllocnistis citrella* Stainton (first recorded on Guam in 1927), and the larvae of *Papilio xuthus* L. (known on Guam since 1925). Gummosis disease of citrus also occurs. Damage by adults of the scarabaeid, *Adoretus sinicus* Burmeister (first recorded on Guam in February, 1949) is now prominent, especially on *Acalypha.* The coccinellid, *Epilachna philippinensis* Dieke, a pest of solanaceous plants, first noted on Guam in November, 1948, now occurs also on Saipan and on Rota.

[2] This is the species described as *Pachyophthalmus alienus* by H. R. Dodge on p. 131 of this issue of the "PROCEEDINGS."

ORTHELLIA CAESARION (Meigen)—Dr. Joyce reported taking this calliphorid fly at the Honolulu airport in February. Dr. Hardy added that a previously unrecorded island locality for this species is Kapaa, Kauai, based on material bred from cowdung on December 12, 1940 by Dr. F. G. Holdaway. Earlier island records by Dr. Swezey ("PROCEEDINGS," 9: 28, 110, 116) are from Kapapala ranch and Hilo, Hawaii, June-August, 1934, and Kawela Bay and Koko Head, Oahu, December, 1934 and January, 1935. It was captured on Niihau in October, 1945 ("PROCEEDINGS," 13: 53).

APRIL 14, 1952

The 556th meeting was held at the H.S.P.A. Experiment Station, on Monday, April 14, at 2:00 p.m., with President Bess in the chair.

Members present: Adachi, Bess, Bianchi, Byran, Carter, Chong, Christenson, Clagg, Dresner, Ford, Fullaway, Hardy, Keck, Look, Macdougall, Maehler, Mitchell, Nakao, Newell, Nishida, Pemberton, Rosa, Sakimura, Steiner, Swezey, Tuthill, Weber and Zimmerman.

Visitor: C. E. Cooley. G. W. Macdougall was unanimously elected a member of the Society.

NOTES AND EXHIBITIONS

NEOCLYTARLUS ATRICOLOR Perkins—Dr. Swezey exhibited, for C. J. Davis, a specimen of this rare cerambycid. It was bred from larvae found in February in stems of *Vaccinium peleanum* at an elevation of 6,700 feet on the Mauna Loa truck trail, Hawaii. The only previous record of *N. atricolor* is the single specimen reared by Dr. F. X. Williams from the same hostplant at about 8,500 feet elevation on the eastern slope of Mauna Kea, above Nauhi gulch, in 1931 ("PROCEEDINGS," 8: 266, 1933).

ETHMIA COLONELLA Walsingham—Mr. Ford exhibited specimens of this oecophorid moth reared from "kou," *Cordia subcordata*, at Barber's Point, Oahu, in March. Described from Oahu (FAUNA HAWAIIENSIS, 1: 507, 1907) it has been known here since at least 1881; later it was reported by Meyrick from the Kei Islands, southwest of New Guinea. An extended account of the species by Dr. Swezey appeared in 1944 ("PROCEEDINGS," 12: 133-135). With the exception of the unidentified, cultivated hostplant from which the type material was bred, *Cordia subcordata* is the moth's only known host.

APTINOTHRIPS RUFUS (Gmelin)—Mr. Sakimura reported collecting this thrips on Mt. Tantalus in December, 1951. This is the first capture of this species on Oahu; it has been known on the island of Hawaii since June, 1944.

ANOMALA EATEN BY PLOVER—Mr. Sakimura reported concentrated flights of the Pacific golden plover (*Pluvialis dominica fulva*) over pineapple fields in the Kunia-Robinson region of Oahu, during March and

April. The birds' droppings along field roads showed a striking difference in *Anomala* content between fields treated with DDT and others not treated, immediately adjacent. In non-treated fields the droppings consisted mainly of adult *Anomala orientalis* (Waterhouse), while those from DDT-treated fields consisted of insects other than *Anomala*. Dr. Pemberton commented that plover are very abundant this year, and are numerous in flooded areas at Ewa, feeding on rat-tail maggots (*Tubifera*). An earlier note on plover feeding on *Anomala* appeared in 1950 in these "PROCEEDINGS" (14: 17).

A THRIPS NEW TO THE ISLANDS—Dr. Carter presented the following: A large colony of *Parthenothrips dracaenae* (Heeger), a thrips gregarious in habit, was discovered on badly scarred leaves of "ti" (*Cordyline terminalis*) in an ornamental planting at Wahiawa, Oahu, March 25, 1952. This is an insect until now unrecorded in Hawaii, although it is a well known injurious greenhouse species in Europe and North America, including California. It is a general feeder with a preference for liliaceous plants. Identification of the insect was made by Mr. Sakimura.

TWO NEW SEPSID FLIES—Dr. Hardy reported collecting *Sepsis biflexuosa* Strobl and its variety *S. biflexuosa curvitibia* Melander and Spuler, at Lualualei, Oahu and on the Ewa coral plain near Ewa beach, Oahu, in February, 1952. Both are new records for the Hawaiian Islands. In fact, they are the first examples of the dipterous family Sepsidae to be reported here. Determined by Dr. Hardy, the identifications were confirmed by C. W. Sabrosky. *S. biflexuosa* was described from Austria (Wein. ent. Zeit., 22: 225, 1893) and is widespread in the Nearctic Region, Europe and the Canary Islands. The variety was described in 1917 (Bull. 143, Wash. State Agr. Expt. Sta.: 28).

ENTOMOGENOUS FUNGI—Mr. Nakao reported that in November, 1951, P. W. Weber sent to Honolulu, from Louisiana, sweet potato weevils, *Cylas formicarius elegantulus* (Summers), parasitized by a fungus later identified by Dr. E. A. Steinhaus as *Beauveria bassiana*. In the laboratory this fungus worked equally well on *Cylas* and *Euscepes postfasciatus* (Fairmaire). At about the same time Mr. Fullaway received from Hawaii, larvae of the phycitid *Cactoblastis cactorum* (Berg), killed by fungus identified by Dr. Steinhaus as either *Beauveria bassiana* or *B. globulifera*. Earlier ("PROCEEDINGS," 14: 355, 1952), Dr. Martin Sherman reported that "probably *B. bassiana* or *B. globulifera*" had been cultured from *Cylas* material which later proved to have come from Poamoho, Oahu.

TARSONEMUS PALLIDUS Banks—Dr. Bess reported a severe outbreak recently of this cyclamen mite on watercress, between Aiea and Pearl City, Oahu. Growth was stunted in extreme cases. According to cress growers the mite has been present in this area for some years. Fumigation with ethylene dibromide and with methyl bromide were both successful, although the latter treatment resulted in some damage to the plants. Either fumigant it is believed would produce satisfactorily clean planting material.

SYNTOMOSPHYRUM INDICUM Silvestri—Miss Chong reported that a male of this introduced eulophid was found upon opening up *Momordica* fruits infested with *Dacus cucurbitae* Coquillett at Makaha, Waianae, Oahu, on April 1. Later: On May 1 large numbers of this parasite were obtained from two papayas heavily infested with *Dacus dorsalis* Hendel larvae, and exposed for two days at Maunawili, Oahu. These records are the first of the recovery of *Syntomosphyrum* in the Territory.

TETRASTICHUS DACICIDA Silvestri—Miss Chong reported that several hundred adults of this African eulophid were bred from *Momordica* collected at Makaha, Oahu, April 1 and 3, 1952. Later, from figs collected at Kalihi-uka, Honolulu, 20 adult *T. dacicida* were reared. These are the first recoveries of this species in the Territory.

CYRTORHINUS FULVUS Knight—Dr. Bess reported the presence of this egg-sucking mirid bug on taro at Waihee, Maui, on March 12, 1952, where it was attacking the eggs of the delphacid, *Tarophagus prosperina* (Kirkaldy). The bug was released on Maui in November, 1951, following the discovery there of the taro leafhopper on October 26, 1951. *T. prosperina,* an immigrant species, was first found in the Islands on Oahu in 1930, and later on Kauai and Hawaii. Identification of *C. fulvus* was made by Dr. Hardy.

APANTELES TRIFASCIATUS Muesebeck—Mr. Fullaway reported this braconid swarming about a *Camellia japonica* plant in Manoa, Honolulu. This species has been reared from larvae of the tineid, *Opogona;* as there was considerable plant trash in the vicinity, the parasite probably issued from lepidopterous larvae feeding in the trash.

MAY 12, 1952

The 557th meeting was held at the H.S.P.A. Experiment Station on Monday, May 12, at 2:00 p.m., with President Bess in the chair.

Members present: Adachi, Balock, Bess, Bianchi, Carter, Chilson, Chong, Christenson, Clagg, Dresner, Flitters, Ford, Fullaway, Haramoto, Hardy, Hinman, Kamasaki, Keck, Look, Macdougall, Maehler, Messenger, Nishida, Pemberton, Rosa, Sakimura, Martin Sherman, Schmidt, Suehiro, Swezey, Tamashiro, Tuthill, Van Zwaluwenburg, Weber and Zimmerman.

Visitors: Doak Cox, Hideo Higa, L. B. Loring, Dr. and Mrs. A. L. Melander, James Nichols, Mrs. Harold St. John, L. Schoening, Mrs. O. H. Swezey and Jit Singh Verma. The name of Mr. Verma, a graduate student at the University of Hawaii, was proposed for membership.

PAPERS

The following were presented by title: F. R. Shaw's "A review of some of the more important contributions to our knowledge of the systematic relationships of the Sciaridae (Diptera)"; and L. J. Dumbleton's "A

note on Aleuroplatus (Orchamus) samoanus Laing (Hemiptera-Homoptera: Aleyrodidae)."

NOTES AND EXHIBITIONS

BRACON HEBETOR (Say)—Dr. Sherman exhibited braconid parasites bred from a local infestation in flour, of the almond moth, *Ephestia cautella* (Walker), which were determined as *B. hebetor*. The infestation was remarkable for the great numbers of the moth present in a small amount of flour.

PLANOCOCCUS CITRI (Risso)—Mr. Zimmerman reported that Dr. Swezey received from C. J. Davis specimens of this mealybug on foliage of *Acacia koaia* from the mountains north of Waimea, Hawaii. Determination was made by Dr. G. F. Ferris. This is both a new hostplant record and a new island record for this coccid (see "INSECTS OF HAWAII," 5: 201, 1948).

DETTOPSOMYIA FORMOSA Lamb—Mr. Tamashiro reported that a drosophilid fly, which he collected on Maui, May 10, 1952, was identified as this species by Dr. Hardy. It is a new island record; described from the Seychelles, this fly has until now been known only from Oahu, where it was first recorded in 1938.

PSEUDHOMALOPODA GUAMENSIS Fullaway—Mr. Fullaway reported that this encyrtid was found in considerable numbers on bamboo infested with *Asterolecanium bambusae* (Boisduval) (and perhaps another coccid), from Kalihi Valley, Oahu, April 23, 1952. This is the first record of this parasite in Hawaii; it was described in 1946 ("INSECTS OF GUAM-II," Bishop Mus. Bull. 189: 209).

TEGONOTUS HIBISCELLA Keifer—Mr. Look reported a new island record for this rust mite. A heavy infestation was found at Alewa Heights, Honolulu, May 5, 1952. The species was first collected February 8, 1945 by Mr. Look in Hilo, Hawaii. The Honolulu specimens were determined by H. H. Keifer. The host plant was *Hibiscus*.

CORRECTION—The recent reference ("PROCEEDINGS," 14: 349, 1952) to rearing *Pachyneuron syrphi* (Ashmead) from the butterfly, *Vanessa cardui* (L.), was based upon a misidentification. The parasite involved was *Pteromalus puparum* (L.), identified by D. T. Fullaway. This record of its recovery (from Waikii, Hawaii) is only the second since its introduction in 1904 and its reintroductions in 1910 and 1918. It was first bred here from *Pieris rapae* (L.) by W. C. Look in September, 1946, at Kilauea, island of Hawaii ("PROCEEDINGS," 13: 28, 1947).

The latter part of the meeting was devoted to the showing of Dr. Melander's excellent moving pictures of solitary Hymenoptera.

JUNE 9, 1952

The 558th meeting was held at the H.S.P.A. Experiment Station, on Monday, June 9, at 2:00 p.m., with President Bess in the chair.

Members present: Adachi, Alicata, Balock, Beardsley, Bess, Clagg, Dresner, Flitters, Ford, Fullaway, Hinman, Joyce, Keck, Look, Macdougall, Maehler, Messenger, Pemberton, Rosa, Swezey, Tuthill, Van Zwaluwenburg, Weber and Zimmerman.

Visitors: Z. Allen Barker, Dr. and Mrs. A. L. Melander, Mrs. O. H. Swezey, Warren K. Wong and H. A. Woolford. Jit Singh Verma was unanimously elected a member of the Society, and Z. Allen Barker was nominated for membership.

NOTES AND EXHIBITIONS

ANOPLOLEPIS LONGIPES (Jerdon)—Mr. Zimmerman reported that he had identified specimens of this ant, collected by E. J. Ford, Jr., on *Hibiscus* at Barber's Point, Oahu, April 17, 1952. This is the first record of the species in Hawaii. It is known from many localities in the Orient, the Indo-Pacific area and elsewhere, including Mexico; it is possible that it reached Oahu from Guam, where it is very common.

FUNGUS ATTACKING COCCIDS—Mr. Beardsley exhibited specimens of the green scale, *Coccus viridis* Green, infested by the "white halo" fungus, *Verticillium lecanii* (Zimmerman) Viegas. Heavily infested colonies of *C. viridis* have frequently been observed on Oahu. Cultures of the fungus, isolated from diseased scales, and reared on agar, were identified by Dr. Paul Lentz of the U. S. Department of Agriculture Division of Mycology and Disease Survey, as this fungus, a species recorded as a parasite of *C. viridis* and other scales in many tropical and subtropical areas. It was originally described from green scale from Java, as *Cephalosporium lecanii*. In addition to *C. viridis*, Mr. Beardsley has found the following scale insects to be hosts of this fungus: *Ceroplastes rubens* Maskell, *Coccus acuminatus* (Signoret), *Eucalymnatus tessellatus* (Signoret) and *Saissetia oleae* (Bernard). All of these scales were from guava in Waikakalaua gulch, Oahu.

PERKINSIELLA VITIENSIS Kirkaldy—Dr. Pemberton reported that on May 14, a plane arrived at the Honolulu airport from Fiji, with several hundred living individuals of the Fiji sugar cane leafhopper in various parts of the plane. It was believed that several thousands of the leafhopper had entered the plane some 9 hours earlier, while it was fueling during a mass flight of the 'hoppers about the Nandi airport. Federal plant quarantine officers gave the plane a thorough treatment with insecticide sprays after its arrival. This species is the vector of "Fiji disease" of sugar cane, a virus disease not known to occur in Hawaii, but of the gravest concern to cane growers here.

Dr. Melander exhibited more of his remarkable motion pictures, showing butterflies, cicadas and other insects in natural surroundings.

JULY 14, 1952

The 559th meeting was held at the H.S.P.A. Experiment Station, on Monday, July 14, at 2:00 p.m., with President Bess in the chair.

Members present: Adachi, Alicata, Balock, Barker, Bess, Bianchi, Bryan, Carter, Chilson, Chong, Fullaway, Gressitt, Haramoto, Hardy, Joyce, Keck, Krauss, Look, Martin Sherman, Suehiro, Swezey, Tamashiro, Tanada, Tuthill, Van Zwaluwenburg and Verma.

Visitors: Miss Maisie Cameron, Charles P. Hoyt, Miss Kazuko Kutaka and L. B. Loring. Mr. Z. Allen Barker was unanimously elected to membership.

PAPER

Dr. O. H. Swezey presented his paper: "A new species of leafminer in Straussia (Lepidoptera: Gelechiidae)."

NOTES AND EXHIBITIONS

LYCTUS CURTULUS Casey—Dr. Swezey exhibited specimens of this beetle which had issued from sapwood of a monkeypod (*Samanea saman*) board, which had been held in a jar since February, 1950. Exit holes of the beetles were very numerous, and adults continue to emerge from the wood. The first record of this insect in Hawaii is from wood of *Sapindus oahuensis* collected by Dr. Swezey at Kealia, Oahu in September, 1934 ("PROCEEDINGS," 9: 34, 1935). There have been no records of its occurence here since then.

AMARYGMUS near MORIO (F.)—Two specimens of this tenebrionid beetle were exhibited by Dr. Swezey. They were collected by C. J. Davis near the fruit fly insectary at Hilo, Hawaii, June 22. This is a considerable distance from Kuhio wharf in Hilo where Mr. Maehler first found this insect in November, 1951, on prop-roots of *Pandanus* ("PROCEEDINGS," 14: 367, 1952).

CERATINA ARIZONENSIS Cockerell—Mr. Fullaway reported that this small bee has twice been collected on Oahu, and is believed to be established here. The first was taken on November 23, 1950 on the University campus by T. Niega; the second capture was made on Kamehameha Heights, Honolulu, March 15, 1952, by P. Lam. The specimens were identified by P. H. Timberlake.

GYRANUSOIDEA sp.—Mr. Fullaway reported rearing five specimens of an undescribed encyrtid of this genus, from an unidentified mealybug, in 1945, in Honolulu. This parasite was confused until now with *Leptomastix dactylopii* Howard, a species imported in 1946, and also well established here. The two insects differ in antennal and wing characters.

AMPHICERUS CORNUTUS (Pallas)—Mr. Krauss reported that adults of this bostrychid were found at Kailua, Oahu attacking newly planted croton cuttings. One of the injured cuttings was bored out for about an inch and one-half at the upper end.

MAUI INSECT RECORDS—Mr. Look repored that *Anaphothrips corbetti* Priesner was causing damage (July 10) to *Vanda Miss Joaquim* and *V. sanderiana* blossoms at Wailuku, Maui. The thrips was not found at Kahului. The aphid, *Macrosiphum luteum* (Buckton) was observed at the same time in great numbers on *Cattleya* and *Dendrobium* at Wailuku and Kahului. These are new island records for both insects.

PROCECIDOCHARES UTILIS Stone—For C. J. Davis the breeding of the "pamakani" gall fly was reported from *Eupatorium glandulosum* collected May 14, 1952, at Puuwaawaa ranch on the north slope of Mt. Hualalai. This is the first time either the hostplant or the fly has been recorded from the island of Hawaii. The area of "pamakani" comprises a compact stand of about one-quarter of an acre, at about 2,500 feet elevation, with scattered plants surrounding the area. Joseph Kaholo, Sr., of Puuwaawaa ranch, said that the plants have been growing in this locality for about 10 years and formerly occupied a dense stand of 3 acres. The plants were heavily infested at the time of Mr. Davis' visit; from 50 stems collected, 210 adult gall flies issued between May 14 and June 13.

JAPANESE LAMPYRIDS INTRODUCED. Dr. Bess reported that during June, 1952, about 6,000 lampyrid beetles were imported from Japan to combat the snail *Fossaria ollula*, the only known vector of the common liver fluke of cattle in Hawaii. The beetles were *Luciola cruciata* Motschulsky and *L. lateralis* Motschulsky. Between 4,500 and 5,000 beetles, and hundreds of their eggs, were released, on the islands of Oahu, Kauai, Maui and Hawaii.

Dr. Alicata gave a brief history of earlier attempts to introduce into Hawaii enemies of the snail vector of liver fluke. The two species now being liberated were imported in 1939 and 1940, together with some Philippine species of lampyrids. None of these importations became established, due, it is believed, to the small numbers released.

AUGUST 11, 1952

The 560th meeting was held at the H.S.P.A. Experiment Station, on Monday, August 11, at 2:00 p.m., with President Bess in the chair.

Members present: Adachi, Bess, Bianchi, Chilson, Christenson, Clagg, Dresner, Fullaway, Gressitt, Ito, Joyce, Krauss, Look, Maehler, Nishida, Rosa, Steiner, Suehiro, Swezey, Tuthill, Van Zwaluwenburg and Verma.

Visitors: C. P. Hoyt and Miss Kazuko Kutaka. Dr. Charles P. Hoyt was nominated for membership.

PAPER

Dr. Swezey presented a paper by C. J. Davis: "New host and insect records from the island of Hawaii."

NOTES AND EXHIBITIONS

BEETLES INTERCEPTED IN QUARANTINE—Mr. Maehler exhibited the following scarabaeid adults recently intercepted at Honolulu:

Anomala cuprea (Hope). Dead in plane from Japan, Honolulu airport, June 16, J. Nichols.

Anomala sp. Dead in plane from Japan, Honolulu airport, July 16, H. Messersmith. Also collected at Haneda airport, Japan, O. O. Stout.

Anomala sulcatula Burmeister. Alive on motor vessel a few miles out of Midway Is., June 26, G. Dyson. Reported common on deck of ship at Midway.

Anomala viridana Kolbe (*A. japonica* Arrow). Alive in plane from Wake Is., Honolulu airport, July 2, Ray Greenfield. The pilot reported many of these beetles seen alive on Wake.

Protaetia orientalis (Gory and Percheron). Alive in plane from Japan, Hickam Field, Honolulu, June 17, W. O'Sullivan.

PROTAETIA FUSCA (Herbst)—Mr. Maehler reported that on August 4, Mr. Androus of the Federal plant quarantine staff captured a specimen of this beetle at Kaneohe, Oahu. This is a considerable extension of its known range on this island.

INSECT RECORDS FROM FRENCH FRIGATES SHOAL—Dr. Joyce reported that on July 25, 1952, while visiting Tern Island, French Frigates Shoal, he found a tick to be the cause of numerous complaints by personnel who were bitten by it. It was identified by G. M. Kohls of the Rocky Mountain Tick Fever Laboratory as *Ornithodoros capensis* Neumann. It was extremely abundant under trash and debris. Species of this genus are known vectors of the spirochaetes which cause relapsing fever in other parts of the world. Dr. Joyce also found the sarcophagid, *Goniophyto bryani* Souza Lopes, to be very abundant; it was the dominant fly on the tiny island.

TYPHLOPS BRAMINUS (Daudin)—It was stated that Hans W. Hansen of the Oahu Sugar Co., Ltd., reported finding numbers of this eyeless ground snake recently at Aiea, while excavation was in progress. In January, 1951, it was found to be very numerous under stones, irrigation flumes, etc., near the manager's residence at Aiea. This is a considerable extension westward of the previously known range of this harmless reptile.

HELIX ASPERSA Muller—For Yoshio Kondo, terrestrial malacologist of the Bishop Museum, it was reported that he had identified as this edible European brown snail, a single specimen, submitted to him by Q. C. Chock of the Board of Agriculture and Forestry, taken on February 14, 1952, in Kaimuki, Honolulu, by Masao Miyamoto. The species has previously been intercepted by inspectors of the Board of Agriculture; it is not believed to be established in Hawaii.

ARGENTINE ANT—Mr. Ito reported that a new area of some 3 acres belonging to the California Packing Corp., at Kunia, Oahu, about 2 miles from Schofield Barracks, was recently found infested by the Argentine ant. He further reported that another ant, *Cardiocondyla nuda* Mayr

var. *minutior* Forel, was found at Opaeula in an area occupied by *Iridomyrmex*. It was perhaps tolerated or overlooked by the Argentine ant because of its minute size.

SEPTEMBER 8, 1952

The 561st meeting was held at the H.S.P.A. Experiment Station, on Monday, September 8, at 2:00 p.m., with Vice-President Weber in the chair.

Members present: Adachi, Balock, Barker, Bianchi, Chilson, Clagg, Dresner, Hardy, Hinman, Hoyt, Ito, Joyce, Keck, Look, Maehler, Messenger, Mitchell, Pemberton, Rosa, Schmidt, Martin Sherman, Suehiro, Swezey, Tamashiro, Tuthill, Van Zwaluwenburg, Verma and Weber.

Dr. Charles P. Hoyt was elected to membership.

PAPERS

The following were presented: D. E. Kimmins' "New Hawaiian Coniopterygidae (Neuroptera)," and "Notes on some dragonflies (Odonata) of the Cook Islands," by M. A. Lieftinck.

NOTES AND EXHIBITIONS

ANOMALA sp.—Mr. Maehler reported that on August 18, James Nichols found a live *Anomala* beetle, as yet unidentified, on the wall of a washroom at the Honolulu airport. Eighteen planes arrived that day from foreign airports, so it is impossible to say where the beetle came from.

IRIDOMYRMEX HUMILIS Mayr—Mr. Ito reported that the Argentine ant is now established at the Helemano Army radio station and nearby pineapple fields near Wahiawa, Oahu. This infestation was found on August 13 and extends about 100 feet within the reservation, and 300 feet into the narrow weedy strip of a second ratoon pineapple field adjoining Helemano gulch. Spread across the paved military road has not yet occurred. *Pheidole* ants had been noticed occupying this particular section of the field during the survey made in December, 1950, though search within the reservation was not made at that time.

VANDUZEA SEGMENTATA (Fowler)—An observation made by Mr. Krauss was reported. This membracid was found in large numbers breeding on "kiawe" trees (*Prosopis*) at Waimanalo, Oahu, August 13. This is a new hostplant record, the sixteenth in a growing list.

OCTOBER 13, 1952

The 562nd meeting was held at the H.S.P.A. Experiment Station on Monday, October 13, at 2:00 p.m., with President Bess in the chair.

Members present: Adachi, Alicata, Balock, Bess, Bianchi, Bryan, Carter, Chilson, Chong, Christenson, Clagg, Dresner, Flitters, Fullaway, Gressitt,

Haramoto, Hardy, Hinman, Hoyt, Hu, Joyce, Keck, Look, Macdougall, Maehler, Messenger, Mitchell, Nakao, Newell, Nishida, Pemberton, Rosa, Sakimura, Schmidt, Martin Sherman, Steiner, Suehiro, Swezey, Tamashiro, Tanada, Tuthill, Van Zwaluwenburg, Verma, Weber, Yamamoto and Zimmerman.

Visitors: George Dyson, Jules Fine, Irving Keiser and J. T. Mason. Irving Keiser and P. Y. Nakagawa were nominated for membership in the Society.

PAPERS

F. A. Bianchi presented his paper: "Thysanoptera of Samoa," and D. T. Fullaway: "Three new species of Eurytoma (Hymenoptera: Eurytomidae)."

NOTES AND EXHIBITIONS

CANTHON HUMECTUS (Say)—Mr. Fullaway reported this dung beetle in enormous numbers at Waikii, Parker Ranch, Hawaii, in September. It was so numerous that it had practically eliminated all material suitable for the breeding of hornflies.

OPIUS OOPHILUS Fullaway—Mr. Maehler reported seeing this parasite of *Dacus dorsalis* Hendel numerous on Bluefield bananas on a fruit stand near Kailua. Probably there had been oviposition by the fly in ripe fruit after being placed on the stand.

ARGENTINE ANT—For Mr. Ito it was reported that the Argentine ant had been found on September 22 in a new area on Oahu: the Army bivouac area along the Pupukea military road in upper Kawailoa-Waimea. Starting at the upper apex of Hawaiian Pineapple Co. Field 4811, the infested area extends 0.8 miles northward along the road, probably occupying the breadth of the grassy plateau and overrunning into several adjoining valleys, even over into the Waimea side at some points. This appears to be a separate infestation from the one at Opaeula, for a considerable area between the two areas is still held by *Pheidole* ants.

TACHYPOMPILUS ANALIS (F.)—Mr. Van Zwaluwenburg reported the presence of this spider-hunting wasp at Mapulehu, Molokai, on September 24, 1952. This is a new island record.

TENODERA AUSTRALASIAE (Leach)—Mr. Rosa reported that on August 12 an H.S.P.A. trainee found the characteristic ootheca of this recently established mantid near Field 52, Oahu Sugar Co., Ltd., just below the point where the Waiahole ditch crosses the main Schofield highway. This is about eight miles almost due north of the nearest previously known locality of this insect.

The meeting then adjourned for the taking of a group picture of the Society. Upon resumption of the meeting, Dr. O. H. Swezey, who is soon to depart for permanent residence in California, was given leis by Miss Adachi and Miss Chong, on behalf of the Society. A scroll expressing the members' admiration and affection for Dr. Swezey, was presented to him; this had been signed by all of the members who could be reached.

ALOHA TO DR. O. H. SWEZEY
October 13, 1952

FIRST ROW (l. to r.) : Hinman, Hardy, M. Sherman, Nakao, Tanada, Verma, Tamashiro, Haramoto, Weber, Sakimura, Tuthill. SECOND ROW (l. to r.): Joyce, Adachi, Suehiro, Chong, Flitters, Yamamoto, Dresner, Mitchell, Rosa, Schmidt. THIRD ROW (l. to r.): Pemberton, Macdougall, Zimmerman. FOURTH ROW (l. to r.): Bess, Fullaway, Steiner, Gressitt, Nishida, Keck, Alicata, Look, Hu, Hoyt, Dr. Swezey, Christenson, Keiser, Maehler, Barker, Mason, Chilson, Newell, Bryan, Carter, Balock, Van Zwaluwenburg, Bianchi, Clagg, Messenger.

On behalf of the Bishop Museum Mr. Bryan presented Dr. Swezey with resolutions detailing his connections with the Museum, and expressing appreciation of his many years of enthusiastic and faithful service; Miss Suehiro presented Dr. Swezey with a lei for the Museum. Remarks by Dr. Pemberton extolled Dr. Swezey's long and valuable service to the H.S.P.A. Experiment Station and his many years of participation in the activities of this Society, of which he was a founder and charter member. Mr. Fullaway, for the Society, then presented Dr. Swezey with a watch, suitably inscribed. Dr. Swezey responded appropriately and went on to speak of the early days of the Society. In closing, he exhibited the manuscript of a paper on the insects associated with the trees of the Hawaiian forests, a project which has interested him for nearly half a century. It is hoped that this manuscript may be published in the near future.

NOVEMBER 10, 1952

The 563rd meeting was held at the H.S.P.A. Experiment Station, on Monday, November 10, at 2:00 p.m., with President Bess in the chair.

Members present: Adachi, Balock, Barker, Bess, Bianchi, Chilson, Clagg, Defibaugh, Dresner, Ford, Fullaway, Gressitt, Hardy, Hinman, Hoyt, Joyce, Keck, Krauss, Look, Maehler, Messenger, Newell, Pemberton, Randall, Rosa, Suehiro, Tamashiro, Tanada, Tuthill and Van Zwaluwenburg.

Irving Keiser and P. Y. Nakagawa were elected to membership in the Society.

PAPER

Dr. Hardy presented his paper: "New Hawaiian Tipulidae (Diptera)."

NOTES AND EXHIBITIONS

HERMETIA ILLUCENS (L.)—For Dr. Swezey it was reported that this stratiomyiid fly was collected in October, 1952, by J. A. Swezey, at Lahaina, Maui. This is a new island record. Although this fly is probably on all the main islands of the Hawaiian group, actual records of it are few. It was first seen on Hawaii in 1930, on Oahu in 1940, and on Kauai in 1942.

TACHYPOMPILUS ANALIS (F.)—Dr. Swezey submitted a new island record for this psammocharid wasp, captured at Lahaina, Maui, in October, 1952, by J. A. Swezey. Mr. Van Zwaluwenburg added that Mr. Davis reported this wasp early in November, 1952, in Hilo, island of Hawaii.

LYCOSA HAWAIIENSIS Simon—Dr. Pemberton reported that twice during the summer of 1952, a resident of Aina Haina, Honolulu, had submitted specimens of this "wolf spider" taken in a house there. The spider was identified by Dr. W. J. Gertsch of the American Museum of Natural History. This appears to be the first record of its presence on Oahu. In

row (l. to r.): Joyce, Adachi, Suehiro, Chong, Fitters, Tamashiro, Dresner, Keck, Alicata, Look, Hu, Hoyt, Dr. Swezey, Macdougall, Zimmerman. Fourth row (l. to r.): Bess, Fullaway, Steiner, Gressitt, Nishida, Keck, Alicata, Look, Hu, Hoyt, Dr. Swezey, Christenson, Keiser, Maehler, Barker, Mason, Chilson, Newell, Bryan, Carter, Balock, Van Zwaluwenburg, Bianchi, Clagg, Messenger.

the "FAUNA HAWAIIENSIS" (2: 506) it is listed from Olaa, Kilauea and Kona on the island of Hawaii, and from Mt. Haleakala on Maui.

CHEIRACANTHIUM sp.—Dr. Hardy reported a third case of a bite by this spider. A three-year-old boy was bitten on the index finger. He evinced sharp pain in the appendage for about one-half hour, and the finger evidently bothered him for several hours. The boy was restless and irritable throughout the entire day, but experienced no other ill effects. The offending spider was a male.

NEW NAME FOR CARROT APHIS—Dr. Hardy called attention to a change of name for the aphis called locally, *Aphis ferruginea-striata* Essig; the correct name is *Sappaphis foeniculus* (Theobald) (see Journ. Econ. Ent., 45: 752, 1952).

NOTES ON HAWAIIAN INSECTS—Mr. Chilson presented the following information concerning insects recently intercepted by Federal plant quarantine inspectors at local airports in baggage, etc., originating in Hawaii and destined for the mainland.

Trionymus lounsburyi Brain (Zimmerman, "INSECTS OF HAWAII," 5:260, 1948). Det. by Harold Morrison; on *Hymenocallis littoralis*, June 2, R. Harding. This appears to be a new hostplant record in Hawaii.

Pulvinaria psidii Maskell. Det. Harold Morrison; on litchi fruit (not stems or leaves), June 22, J. R. Nichols. A new hostplant for this species here.

Aspidiotus lataniae Signoret. Det. Harold Morrison; on *Alyxia olivaeformis*, June 13, H. A. Woolford. Perhaps a new hostplant for this polyphagous diaspid. Morrison seems not to have accepted the usage of *Hemiberlesia* for this species.

Bradybaena similaris (Férrusac). Det. H. A. Rehder. In recent identifications of the snail *Eulota similaris*, the U. S. National Museum has been using the above generic name, placing the snail in the family Bradybaenidae.

Brachymeria discreta Gahan. Det. B. D. Burks. From airplane, May 18, G. Pearsall. This is the chalcid first recorded from Oahu in July, 1950 ("PROCEEDINGS" 14:223).

Lamprolonchaea aurea (Macquart). Det. C. W. Sabrosky. From airplane, June 7, G. Pearsall. This fly was first taken on Oahu in January, 1951 ("PROCEEDINGS," 14:363, 408).

In discussing recent collecting in Micronesia, Mr. Krauss mentioned that the European corn borer and *Adoretus sinicus* Burmeister are among the serious pests on Guam. Dr. Gressitt added that *A. sinicus* is also on Koror, in the Palau group, where it has been known since 1947.

Dr. Newell discussed his recent, continuing, studies on the chigger-like mites of the Pacific Coast states. They are a unique group in that more is known about the larvae than about the adults in most species. Many of the genera are known only as larvae, others only as adults, with the result that the taxonomy of the group has developed along two divergent lines. By obtaining eggs and young from adult females, Dr. Newell was able to make many new correlations. This procedure is far simpler than rearing larvae to adulthood because it eliminates the need for rearing the larval hosts. The adults are not parasitic.

DECEMBER 8, 1952

The 564th meeting was held at the H.S.P.A. Experiment Station, on Monday, December 8, at 2:00 p.m., with President Bess in the chair.

Members present: Balock, Barker, Bess, Bianchi, Bonnet, Chilson, Chong, Clagg, Dresner, Flitters, Fullaway Haramoto, Hardy, Hoyt, Hu, Joyce, Keck, Krauss, Look, Maehler, Messenger, Newell, Nishida, Pemberton, Randall, Rosa, Martin Sherman, Steiner, Suehiro, Tamashiro, Tanada, Tuthill, Van Zwaluwenburg, Weber, Yamamoto and Zimmerman.

Visitors: Miss Shizuko Maeda and Douglas P. Wilton. The latter, a graduate assistant in Entomology at the University of Hawaii, was nominated for membership in the Society.

The following officers were elected for the coming year:

President.....P. W. Weber
Vice-President.....L. F. Steiner
Secretary-Treasurer.....R. H. Van Zwaluwenburg
Additional Member of Executive Committee....I. M. Newell

President-elect Weber took the chair, and Dr. Bess presented the annual address of the retiring President. His subject was the status of the Mediterranean fruit fly in Hawaii as affected by the advent of the oriental fruit fly to these islands.

Eight papers were presented for publication.

NOTES AND EXHIBITIONS

SCALES ON KIAWE—Mr. Krauss reported a new hostplant record for two scales insects. Leaves of "kiawe" (*Prosopis chilensis*) at Waimanalo, Oahu were found infested during July, with *Aspidiotus cyanophylli* Signoret and *Aspidiotus lataniae* Signoret. Identifications were by Harold Morrison.

HETEROSCHEMA sp.—Mr. Chilson reported that a female of this pteromalid wasp, identified by B. D. Burks, was captured by H. Androus on an airplane departing from Honolulu on July 20. The insect was found aboard the plane so it is by no means certain that it is established here.

TETRASTICHUS DACICIDA Silvestri—Miss Chong reported the first recovery of this introduced larval parasite of *Dacus dorsalis* Hendel from the island of Hawaii. In April, 1952 it was recovered on Oahu (see p. 8, this issue of the "PROCEEDINGS"). Guava fruits collected October 23, 1952 by C. J. Davis at Kaalala gulch, Hawaii yielded 35 fly puparia from which four of the parasites were bred. The insect was first released on Hawaii in March, 1950; Mr. Davis' material was identified by Mr. Weber.

POLISTES EXCLAMANS EXCLAMANS Viereck—Dr. Hoyt reported that this wasp is now well established at the Bishop Museum, Honolulu. The nearest to the city it was previously known to occur, was in Civilian Housing Area III, near Pearl Harbor.

CERATINA ARIZONENSIS Cockerell—Mr. Fullaway reported that Harry Nakao found the nest of this bee for the first time in Hawaii, in a dead, dry flowering stem of *Vanda* orchid at Kalihi, Honolulu, November 18. About a dozen bees, ready to emerge, were found in two inches of stem. The first discovery of this bee in the Islands was on Oahu in November, 1950 (see p. 11) of this issue of the "PROCEEDINGS").

ANOPLOLEPIS LONGIPES (Jerdon)—Mr. Chilson reported that numbers of this ant, identified by Dr. Marion R. Smith, were found on flowers leaving Oahu for the mainland in July and in September, by Federal plant inspectors. This is the ant, first found in April, 1952 at Barber's Point, Oahu by Mr. Ford (see p. 10) of this issue of the "PROCEEDINGS").

Patriciella, new name

Patricia Van Zwaluwenburg, 1947 (Proc. Hawaiian Ent. Soc., 13:113).

A new name for *Patricia,* which I used in 1947 for a physodactyline elaterid from West Australia, is necessary because that name is preoccupied by *Patricia* Fox, 1940, for a nymphalid butterfly genus (Trans. Amer. Ent. Soc., 66: 177). For *Patricia* 1947, I propose *Patriciella,* the generotype of which is *Patricia australica* Van Zwaluwenburg, 1947.

R. H. Van Zwaluwenburg

A Note on Aleuroplatus (Orchamus) samoanus Laing (Hemiptera-Homoptera: Aleyrodidae).

By L. J. DUMBLETON
ENTOMOLOGICAL RESEARCH STATION, NELSON, N.Z.

Aleuroplatus samoanus was described by Laing (1927) from croton leaves from Upolu, Western Samoa, and later recorded by Dozier (1928) from leaves of citron (*Citrus medica*) collected by F. L. Washburn on his south Pacific expeditions in 1923 and 1926. The exact locality of the Washburn material is in some doubt, but it is either Hikueru in the Tuamotos, or Tahiti in the Society group, or both. The leaves were said to be "extremely heavily infested."

In this note I record this species from orange from Rarotonga, Cook Islands. These leaves also were very heavily infested, and the insect is one of the main pests of orange on the island.

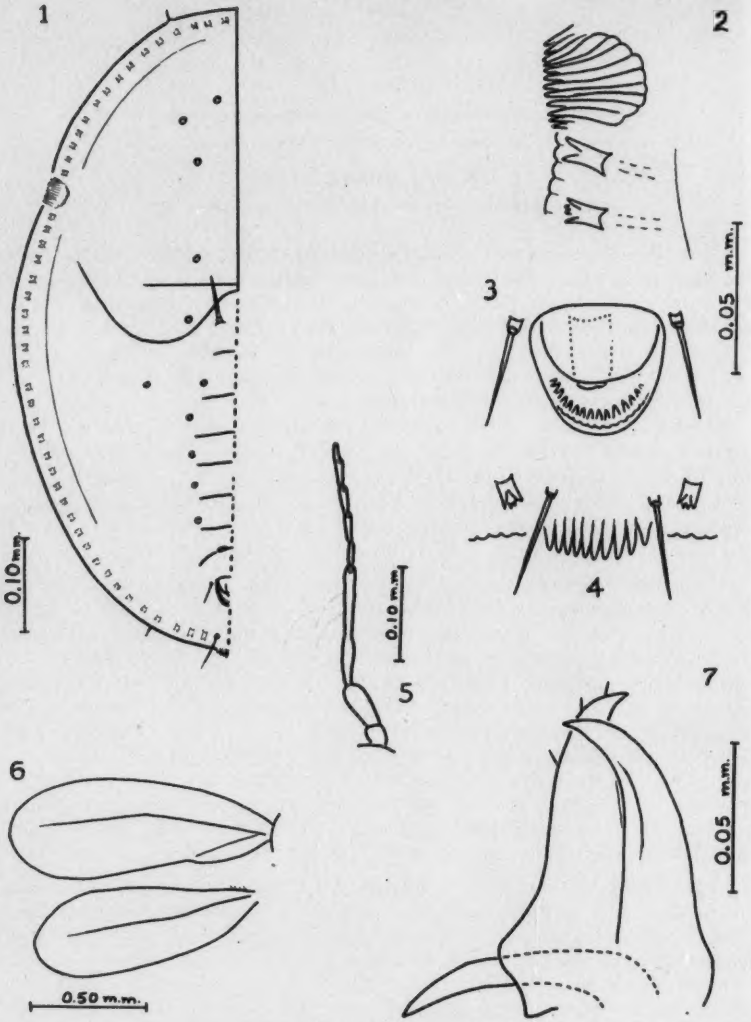
The following notes refer to points on which Laing's and Dozier's descriptions of the pupa case are at variance with one another, or with my specimens. The adult is here described for the first time.

Pupa case (figure 1). The waxy covering of the pupa case shows a radial arrangement of dots. The small setae at very remote intervals around the margin mentioned by Laing are not present, nor are the two short setae which he figures on the operculum. Laing figures only the anterior marginal setae, but Dozier figures both anterior and posterior setae, as in my specimens. Neither Laing nor Dozier figures all the circular pores; these are shown in figure 1. Dozier's figure does not show correctly the shape of the thoracic suture, nor the correct segmentation of the abdomen. Laing shows a submarginal line anteriorly, and this is present in my specimens behind the thoracic spiracle also. The lingula (figure 3) is parallel-sided and rounded apically. The thoracic and abdominal tracheal combs are shown in figures 2 and 4.

Adult male. Colour pale yellowish. Antennae (figure 5) 7-segmented; segment 1 half as long as 2; 3 as long as 4-7 combined, with an apical sensilla; 4 and 5 subequal, 5 with an apical sensilla; 6 and 7 subequal, slightly longer than 5, 6 with an apical sensilla; 7 with a sensilla at distal end of the thicker basal portion, flagellum, or thinner apical portion, shorter than base. Segments 3-7 imbricated. Wings (figure 6) white, unspotted; forewings with only Rs and Cu present; Rs reaches nearly to wing tip, with a flexure at mid-length. Hind wing with a single long vein present. Male genitalia (figure 7) with claspers long, curved apically, setae present but not strongly developed; copulatory organ as figured.

LITERATURE CITED

Laing, F. 1927. Insects of Samoa, Part 2, Fasc. 1: 43-45, text fig. 3.
Dozier, H. L. 1928. Journ. Agr. Research, 36, No. 12: 1002-1005, figs. 3-5.



Aleuroplatus (Orchamus) samoanus Laing

1. Pupa case, dorsal aspect.
2. Thoracic tracheal comb.
3. Vasiform orifice.
4. Abdominal tracheal comb.
5. Adult, antenna.
6. Adult, wings.
7. Adult, ♂ genitalia.

A new Species of Leafminer in Straussia (Lepidoptera: Gelechiidae).

By O. H. SWEZEY

Aristotelia straussiella, new species

Male and *female,* 10 mm. Head and thorax pale ferruginous, face the same. Palpi fuscous, 2nd and 3rd segments with subapical ochreous band. Antennae ochreous, ringed with fuscous, especially towards apex and along dorsal margin towards apex; cilia light gray. Hind wings gray; cilia light gray. Legs and tarsi ochreous, banded with fuscous.

Reared by O. H. Swezey from mines in leaves of *Straussia kaduana* and *Straussia mariniana.* Two examples from Mt. Tantalus, Oahu, March 29, 1936, and three examples from Mt. Tantalus, Oahu, November 18, 1934.

Holotype male and allotype female in type collection of the Hawaiian Entomological Society; paratypes in the collection of the Experiment Station, Hawaiian Sugar Planters' Association.

This species is distinct from *Aristotelia gratula* Meyrick ("PROCEEDINGS," 7:101, 1928), described from a single example reared by O. H. Swezey from a mine in a leaf of *Straussia kaduana* on Mt. Tantalus, Oahu, January 30, 1913.

A Review of some of the more important Contributions to our Knowledge of the systematic Relationships of the Sciaridae (Diptera)

By F. R. SHAW
DEPARTMENT OF ENTOMOLOGY, UNIVERSITY OF MASSACHUSETTS

The family Sciaridae is composed, on the whole, of relatively small, obscure, dark-colored gnats. The taxonomy of the group is somewhat difficult because the size of the insects requires preparation of slide mounts of wings and male genitalia for microscopic examination. Nevertheless, the group is an interesting one and merits investigation.

The sciarids are not of great economic importance. A few species cause damage to mushrooms in cultivation and also to potato tubers. Some of my preliminary observations indicate that the larvae may be involved in the spread of soft rot of carrots in storage. To the geneticist, the group is of considerable importance. The chromosomes of the salivary glands are large and easily studied. Moreover, these flies are relatively easy to culture and have a short life cycle. The embryology of the group has been studied by Butt, 1934.[1]

This paper developed as a result of a review of the world literature of the group by the author, who is currently engaged in a study of Hawaiian Sciaridae. It should save much effort by later workers.

The Sciaridae have affinities with the Mycetophilidae, the Cecidomyiidae and the Bibionidae. They have been included by various authors as a subfamily of the Mycetophilidae. Enderlein, apparently in agreement with Loew's observation in 1862, at one time proposed that the Sciarinae should be united with the Lestremiinae of the Cecidomyiidae to form a distinct family. Subsequent workers have not followed this grouping.

The Sciaridae can be recognized by the venation, the presence of a dorsal eye-bridge above the base of the antennae, the presence of a midpleural pit, and the coxae only moderately elongated (in contrast with the Mycetophilidae). The larvae have dark heads, eight pairs of spiracles and white bodies. A few species are gregarious and travel in large numbers, the so-called "armyworms" or "Heerwurms." *Sciara beebei* Shaw is an example of such a form. It was observed by Dr. William Beebe and has been recorded in his book, "HIGH JUNGLES."

The first comprehensive treatise on the group was that of Winnertz. His monograph, "Beitrag zu einer Monographie der Sciariden," was published in 1867. To distinguish his major categories, Winnertz used wing venation, relative size of wing and abdomen, shape of antennal segments and color of halteres. In general, the same characters are used today except that for species determination, male genitalia are considered to be

[1] See list of references, appended to this article, for this and similar citations.

of primary importance. Winnertz recognized seven genera: *Sciara, Trichosia, Cratyna, Corynoptera, Bradysia, Epidapus* and *Zygoneura.*

Skuse contributed to our knowledge of Sciaridae in his monograph of the Diptera of Australia which was published in 1888. He recognized the same genera listed by Winnertz and described approximately 60 new species.

Rübsaamen, 1894, stated that there were over 300 species of sciarids described at that time. His work included keys to the ten genera which he recognized. Rübsaamen proposed the following genera as new: *Metangela, Odontonyx, Rhynchosciara* and *Hybosciara.* He included keys to the species he described.

Kieffer, 1903, described three new genera of the Sciaridae: *Peyerimhoffia, Dasysciara* and *Mycosciara.*

In 1904, Meunier monographed the Cecidomyiidae, the Sciaridae and the Mycetophilidae of the Baltic Amber. He described six new genera of Sciaridae: *Palaeoheterotricha, Willistoniella, Heeriella, Cerato, Palaeognoriste* and *Sciarella.* In his treatise he included descriptions of 38 new species and six new varieties.

Enderlein, 1911, published an extensive paper entitled "Die phyletischen Beziehungen der Lycoriiden und ihre systematische Gliederung." He recognized two subfamilies, the Cratyninae and the Lycoriinae (= Sciarinae). Enderlein recognized 24 genera of which nine were new. The new genera were *Amesicrium, Scythropochroa, Psilomegalosphys, Megalosphys, Trichomegalosphys, Euricrium, Zygomma, Apelmocreagris* and *Ceratiosciara.* Enderlein described 44 new species of sciarids in this paper.

Johannsen, 1912, included the sciarids as a subfamily in his monograph of the fungus-gnats of North America. Enderlein's monograph slightly antedated that of Johannsen who noted the publication but did not follow it. Johannsen included the following genera in his treatment: *Eugnoriste, Manota, Pnyxia, Trichosia, Zygoneura, Metangela, Phorodonta, Sciara* and *Rhynchosciara.*

Brunetti, 1912, recognized only the genus *Sciara* as occurring in British India. He described 36 new species of the genus from the area.

Frey, 1913, published a comprehensive study of the mouthparts of Mycetophilidae, Sciaridae and Cecidomyiidae in which he indicated the relationships of these families.

Schmitz, 1915, described three new genera of Sciaridae having degenerate females. In 1918, the same author monographed the genera of sciarids having reduced maxillary palpi. In his paper, he presented a synopsis of the genera involved.

Pettey, 1918, revised the North American species of the genus *Sciara.* He proposed a new genus, *Neosciara,* for those species of *Sciara* having the media and cubitus without setae. Pettey described five new species of *Sciara* and 25 new species of *Neosciara.*

Edwards, 1925, in his monograph of the British Mycetophilidae followed neither Enderlein nor Pettey. He included the following genera: *Zygoneura, Trichosia, Phorodonta, Sciara, Plastosciara, Peyerimhoffia* and *Epidapus*. He considered that *Pnyxia* should be included with the Sciophilinae.

Tonnoir and Edwards, 1927, monographed the Mycetophilidae of New Zealand. They included four genera of Sciarinae: *Sciara, Scythropochroa, Ohakunea* and *Neopnyxia,* of which the last two were new. A total of 20 species were recognized, 18 being new.

Edwards, 1928, included a key to the species of *Sciara* and *Phorodonta* in his monograph of the Nematocera from the Federated Malay States Museum. This key is of particular value to anyone considering the Sciaridae of Oceania.

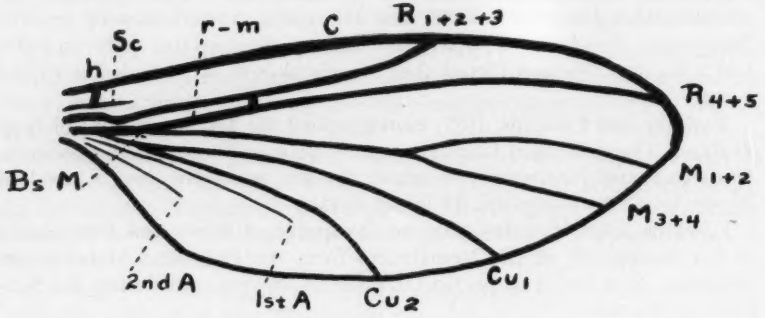
Tonnoir, 1929, monographed the Australian fungus-gnats. He recognized four genera of sciarids: *Sciara, Zygoneura, Trichosia* and *Austrosciara*. Tonnoir recognized 66 species of sciarids from Australia.

Edwards, 1929, in his study of Philippine Nematocera included ten species from the region, of which three were new.

Lengersdorf, 1930, monographed the group as the Lycoriidae, in part 7 of Lindner's "Die Fliegen der palaearktischen Region." He recognized four subfamilies: the Cratyninae, the Megalosphyinae, the Lycoriinae and the Zygoneurinae. Lengersdorf recognized 21 genera and 220 species as occurring in the Palaearctic region. The genera recognized by Lengersdorf are: *Cratyna* Winn., *Scythropochroa* End., *Phorodonta* Coq., *Fungivorides* Ldf., *Psilomegalosphys* End., *Trichosia* Winn., *Geosciara* Kieff., *Peyerimhoffia* Kieff., *Dasysciara* Kieff., *Plastosciara* Berg, *Mycosciara* Kieff., *Sciaraneura* Ldf., *Epidapus* Hal., *Allostoomma* Schmitz, *Hyperlasion* Schmitz, *Aptanogyna* Börner, *Rhynchosciara* Rübs., *Psilosciara* Kieff., *Bradysia* Winn., *Lycoria* Meig., *Zygoneura* Meig.

Edwards, 1931, in "Fauna Sumatrensis" listed 24 species from that island. Of these ten were new.

Frey, 1942, has made the most recent study of the family Sciaridae on the basis of the world genera. He recognized 42 genera of which ten are new. While I agree in general with Frey's categories, I do consider that his recognition of genera on the basis of absence or presence of macrotrichia on veins, or certain portions of the veins, is somewhat open to question. I have translated Frey's keys and have prepared a key based on the genera recognized by him. I do not agree with the interpretation of the wing venation as advanced by Frey; the accompanying sketch will illustrate the terminology I prefer. It will be noted that the Comstock-Needham system is followed except for the radial field. Here I follow Alexander's interpretation that the first branch of radius is a compound vein consisting of R_{1+2}. The second element is considered by Edwards, 1925, to consist of R_{4+5}. I consider that the modified Comstock-Needham system is simpler to use than that of Frey which requires the use of the symbols x and y for portions of the veins.



WING OF SCIARA MEIGEN

Synopsis of the genera of Sciaridae

(Modified from Frey, 1942)*

1. Maxillary palpi 3-segmented (not including the palpifer)..... 2
   Maxillary palpi 1 or 2-segmented. Eyes are often more or less naked..... 26
2. Both branches of radius and M_{1+2} with setae. Usually M_3 and both branches of cubitus bear setae..... 3
   Only the radius with macrotrichia..... 14
3. Wing surface with long macrotrichia..... 4
   Wing surface lacking macrotrichia, (microtrichia may be present) except in a few species of *Sciara* which have macrotrichia along hind margin of wing.... 8
4. The basal section of M appears to originate from Cu_1. Eye-bridge incomplete ..... **Heterotricha** Loew
   The basal section of M and the petiole of cubitus appearing to originate from a common base..... 5
5. Costa not extending beyond tip of R_{4+5}. Origin of Rs (R_{4+5}) beyond middle of wing. Hypopygium relatively complicated..... **Ohakunea** Tonnoir and Edwards
   Costa extends beyond tip of R_{4+5}..... 6
6. Fork of media narrow, not convex..... 7
   Fork of media wide, convex. Petiole of Cu longer than basal section of M ..... **Metangela** Rübsaamen
7. Petiole of cubitus equal to or shorter than the basal section of M..... ..... **Trichosia** Winnertz
   Petiole of cubitus longer than basal section of M..... **Trichomegalosphys** Enderlein
8. Petiole of cubitus equal to or longer than basal section of M. Coxae and legs elongate 9
   Petiole of cubitus shorter than basal section of M. (If the costa extends only halfway between R_{4+5} and M_{1+2} and the claws are toothed see also *Phorodonta* in which genus the petiole of cubitus is often shorter than the basal section of M)..... 12
9. Both branches of media and cubitus with macrotrichia..... 10
   Only the upper branch of media (M_{1+2}) with macrotrichia. M_3 and both branches of cubitus lack macrotrichia..... **Phytosciara** Frey

* The author wishes to express appreciation to Dr. C. P. Alexander for checking this key.

10. R_{4+5}, r-m crossvein, basal section of M and petiole of media and of Cu with macrotrichia 11
Petiole of media, r-m crossvein and basal section of M without setae..... **Phorodonta** Coquillett
11. Petiole of M shorter than vein M_3..... **Sciarella** Meunier
Petiole of M longer than vein M_3. Microtrichia of wing extraordinarily long..... **Pseudosciara** Schiner
12. Both branches of media and of cubitus with setae..... 13
Only M_{1+2} with setae, M_3 and both branches of cubitus naked..... **Merianina** Frey
13. r-m crossvein with setae, body slender, dorsocentrals strong..... **Leptosciara** Frey
r-m crossvein lacks setae, body stout, dorsocentrals hairlike..... **Sciara** Meigen
14. Proboscis elongated, as long as or longer than head..... **Eugnoriste** Coquillett
Proboscis not elongated..... 15
15. Undersurface of head snout-like..... **Rhynchosciara** Rübsaamen
Undersurface of head not snout-like..... 16
16. Thorax strongly arched, extending beyond the head..... **Hybosciara** Rübsaamen
Thorax does not extend beyond the head..... 17
17. Fork of media wide, bell-shaped. Flagellar segments of male petiolate, elongate and verticillate ..... **Zygoneura** Meigen
Fork of media not extraordinarily convex, not bell-shaped. Antenna of males not as above..... 18
18. Eyes naked..... 19
Eyes hairy 20
19. Basal section of M with macrotrichia..... **Decembrina** Frey
Basal section of M lacks macrotrichia. Wings often reduced..... **Psilosciara** Kieffer
20. Wings of males and females normally developed..... 21
Wings at least in one sex reduced or with reduced venation..... 24
21. r-m crossvein with macrotrichia..... 22
r-m crossvein with only 1 or 2 macrotrichia at most on apex..... 23
22. Spurs at apex of meso- and metathoracic tibiae subequal. Third palpal segment as a rule longer than the second..... **Neosciara** Pettey
Spurs at apex of meso- and metathoracic tibiae not subequal. Second and third palpal segments subequal..... **Scaptosciara** Edwards
23. Spurs at apex of meso- and metathoracic tibiae of equal length. Third palpal segment usually longer than second..... **Lycoriella** Frey
Spurs at apex of meso- and metathoracic tibiae not equal. Second and third palpal segments subequal..... **Uddmania** Frey
24. Venation reduced in wings of one or both sexes..... 25
Venation not reduced but wings are shortened..... **Bradysia** Winnertz
25. Wings of female normal in size. Wings of male reduced and with reduced venation..... **Heterosciara** Lengersdorf
Wings of female reduced and venation reduced. Male unknown..... **Rübsaameniella** Meunier
26. Maxillary palpi 2-segmented..... 27
Maxillary palpi 1-segmented. (In *Peyerimhoffia brachyptera* the male has a tiny tubercle-like remnant of second segment)..... 33
27. Wings normally developed..... 28
Wings reduced or lacking..... 32
28. Media and cubitus with macrotrichia..... 29
Media and cubitus lack macrotrichia..... 30
29. Palpal segments subequal in length. Origin of petiole of M near base of radial sector..... **Lestremioides** Frey
Second palpal segment shorter than first. Origin of petiole of M more proximad of base of the radial sector..... **Mouffetina** Frey
30. Terminal paired spurs on meso- and metathoracic tibiae equal in length..... 31
Meso- and metathoracic tibiae each with a single spur..... **Peniosciara** Frey
31. r-m crossvein with macrotrichia. Ovipositor very long..... **Plastosciara** Berg
r-m crossvein lacks macrotrichia..... **Cosmosciara** Frey
32. Wings as large as halteres..... **Dasysciara** Kieffer
Both wings and halteres lacking..... **Coenosciara** Lengersdorf

33. Antennae 2+10-segmented.....**Dodecasciara** Edwards
Antennae 2+14-segmented..... 34
34. Antennae of females very short, about one-fourth length of wing.....
.....**Ceratiosciara** Enderlein
Antennae at least one-half length of wing..... 35
35. Segments of flagellum truly verticillate.....**Epidapus** Haliday
Segments of flagellum with shorter, ordinary bristles..... 36
36. Wings normal. At most sometimes reduced in males..... 37
Wings in females reduced or lacking. Halteres often lacking..... 39
37. r-m crossvein with macrotrichia. Fork of media broadly triangular.....
.....**Sciaraneura** Lengersdorf
r-m crossvein lacking macrotrichia..... 38
38. Pulvilli antler-like. Empodium reduced.....**Mycosciara** Kieffer
Pulvilli normal or reduced.....**Scythropochroa** Enderlein
39. Meso- and metathoracic tibiae with two terminal spurs..... 40
Meso- and metathoracic tibiae each with a single spur. Eyes naked.....
.....**Soudekia** Vimmer
40. Empodium present..... 41
Empodium and puvilli lacking. Eyes of males hairy, those of female naked
.....**Calcaromyia** Vimmer
41. Pulvilli present with long club-shaped bristles.....**Aptanogyna** Börner
Pulvilli lacking.....**Peyerimhoffia** Kieffer

Frey recognizes two divisions of the genus *Sciara*: *Sciara s. str.* and *Apelmocreagris* End. In the genus *Neosciara* he considers there are six subgenera: *Dendrosciara, Semnomyia, Schwenckfeldina, Prosciara, Chaetosciara* and *Neosciara s. str.* He has presented a synopsis of the characteristics used to separate these groups. In *Lycoriella* Frey considers that there are three subgenera: *Hemineurina, Diorychophthalma* and *Lycoriella s. str.*

In 1948, Shaw presented a study of the comparative morphology of the thoraces of the fungus-gnats. In this he indicated the reasons for maintaining the sciarids as a distinct family. Of all the genera examined, *Sciara* and its allies differed from the mycetophilid genera by the possession of a midpleural pit.

Frey, 1948, presented a revised classification of the Sciaridae. This included only the genera and the species of northern Europe. Frey now considers that some of the characteristics previously used to distinguish the genera of these flies are variable. Hence in his most recent work he has stressed the number of rows of facets in the eye-bridge, the number and structure of the palpal segments and the male genitalia as of primary importance. Frey included keys to the 13 genera and to the species of Sciaridae of northern Europe. He has figured the male genitalia for most of the species.

Frey has enlarged the concepts of the genus *Bradysia* to include all species of sciarids having three-segmented maxillary palpi, hairy eyes, two subequal spurs on meso- and metathoracic tibiae and an eye-bridge consisting of two rows of ommatidia. Following this concept *Bradysia* becomes the largest genus of sciarids (in Europe). Frey includes a key to the following subgenera of *Bradysia: Lamprosciara* n. subg., *Diorychophthalma* Frey, *Bradysia s. str., Schwenckfeldina* Frey, *Xenopygina* n. subg., *Neosciara* Pettey, *Hemineurina* Frey, *Dendrosciara* Frey and *Chaetosciara* Frey. He has erected a new genus *Spathobdella* for *Sciara cunctans* (Winn.).

Summary

It is with the hope of stimulating more work in the Sciaridae that the present paper is written. It is thought that such a treatment will serve to bring together the more important references on this group of flies thus making the search of literature easier for other investigators.

In general, there appear to be two schools of thought regarding the taxonomy of the Sciaridae. The one is represented by Johannsen, Edwards, Tonnoir, *et al.;* this group of workers has preferred to recognize comparatively few genera. The second group, represented by Enderlein, Frey *et al.* would recognize many genera (as many as 42). The author is more inclined to agree with the concepts of Edwards and Johannsen, i.e., to keep the number of genera small.

Editor's Note: The following synonyms and changes of name appear in Frey's 1948 paper, on the pages indicated but are not included in Dr. Shaw's present paper.

Psilosciara Kieffer (in part) and *Decembrina* Frey are listed as synonyms of *Dendrosciara* Frey, a subgenus of *Bradysia* Winnertz (p. 55).

Heterosciara Lengersdorf and perhaps *Rübsaameniella* Meunier are listed as synonyms of *Bradysia s. str.* (p. 66).

Uddmania Frey, *nec* Bergroth, changed to *Uddmaniella* Frey (p. 86).

Cosmosciara Frey placed as a subgenus of *Plastosciara* Berg (p. 88).

REFERENCES

Alexander, C. P.
1928. A comparison of the systems of nomenclature that have been applied to the radial field of the wing in the Diptera. Proc. Intern. Congress Ent. 4:700-707, pls. 1-3.

Beebe, W.
1949. Fauna Jungles. Duell, Sloan & Pearce, New York City, N. Y.

Brunetti, E.
1912. Fauna of British India, including Burma and Ceylon. Diptera Nematocera. Taylor & Francis, London, England. 581 pp. illus.

Butt, F. H.
1934. Embryology of Sciara (Sciaridae: Diptera). Ann. Ent. Soc. Amer. 27:565-579, pls. 1-2.

Edwards, F. W.
1925. British Fungus-gnats (Diptera, Mycetophilidae). . . . Trans. Ent. Soc. London 1924:505-670, figs. 1-4, pls. 49-61.
1928. Diptera Nematocera from the Federated Malay States Museum. Jour. Fed. Malay States Mus. 14:1-139, pls. I-II.
1929. Philippine Nematocerous Diptera III. Not. Ent. 9:70-81, figs. 1-2.
1931. Fauna Sumatrensis. Tijd. v. Ent. 74:262-278, figs. 1-14.
1941. Notes on British Fungus-gnats. Ent. Mo. Mag. 77:21-82, figs. 1-9.

Enderlein, G.
1911. Die phyletischen Beziehungen der Lycoriiden und ihre systematische Gliederung. Arch. f. Naturgesch. (1911):116-201, 2 pls.

Frey, R.
1913. Über die Mundteile der Mycetophiliden, Sciariden und Cecidomyiiden. Acta Soc. Fauna Flora. Fenn. 37, No. 2: 54 pp., 4 pls., 1 fig.

1942. Entwurf einer neuen Klassifikation der mückenfamilie Sciaridae. Not. Ent. 22:5-44, figs. 1-12.
1948. Entwurf einer neuen Klassifikation der mückenfamilie Sciaridae. II Die nordeuropäischen Arten. Not. Ent. 27:33-92, figs. 1-136.

Johannsen, O. A.
1912. The Mycetophilidae of North America. Maine Agric. Exp. Sta. Bul. 200:57-146, figs. 24-267.

Kieffer, J. J.
1903. Description de trois genres nouveaux et de cinq espèces nouvelles de la Famille des Sciaridae. Ann. Soc. Sci. Brux. 27:196-204, figs. 1-3, 1 pl.

Lengersdorf, F.
1924. Über die Winnertzsche Sciaridensammlung in Bonn. Wien. Ent. Zeit. 41:6-12.
1929. Les Sciarides (Lycoriidae) de la collection de J. W. Meigen. Encycl. Ent. V:55-61, figs. 2.
1930. Lycoriidae in Lindner's Die Fliegen der palaearktischen Region. 7:1-71, figs. 1-29, tbls. 1-4.
1931. Bemerkungen zu den Zetterstedtschen, Staegerschen und Holmgrenschen *Sciara*-Typen. Deutsch. Ent. Zeit. 1930:49-56.

Loew, H.
1862. Diptera of North America. Smithsonian Misc. Collec. Monograph Part I:1-220, tbls. 1-2.

Meunier, F.
1904. Monographie des Cecidomyidae, des Sciaridae, des Mycetophilidae et des Chironomidae de l'Ambre de la Baltique. Sciaridae Pt. II. Ann. Soc. Sci. Brux. 28:49-89.

Pettey, F. W.
1918. A revision of the genus *Sciara* of the family Mycetophilidae. Ann. Ent. Soc. Amer. 11:319-343, pls. 30-31.

Rübsaamen, E. H.
1894. Die aussereuropäischen Trauermücken des Konigl. Museums für Naturkunde zu Berlin. Berlin Ent. Zeit. 39:17-42, pls. 1-3.

Schmitz, H.
1915. Drei neue Gattungen von nematoceren Dipteren mit degenerierten Wiebchen. Tijd. v. Ent. 58:281-291, tbls. 11-12.
1918. Neue Beiträge zur Kenntnis der Sciariden mit reduzierten Maxillarpalpen. Tijd. v. Ent. 61:88-110, figs. 1-2.

Shaw, F. R.
1941. Some new species of the genus *Sciara* from Canada. Can. Ent. 73:174-175, 2 figs.
1941. New Sciarinae from Oklahoma and New Mexico. Amer. Midland Natl. 26:320-324, 6 figs.
1948. A contribution to the phylogeny of the Mycetophilidae. Ann. Ent. Soc. Amer. 41:189-199, pls. 1-3.

Shaw, F. R. and **Shaw, M. M.**
1950. *Sciara* (*Neosciara*) *beebei*, a new species of Sciaridae having migratory larvae. Bull. Brooklyn Ent. Soc. 45:14-16, figs. 1-2.

Skuse, F.
1888. Diptera of Australia. Proc. Linn. Soc. N. S. Wales, Series 2, Vol. 3:657-725, pl. XII.

Tonnoir, A. L.
1929. Australian Mycetophilidae. Proc. Linn. Soc. N. S. Wales 54:584-614, pls. 22-23.

Tonnoir, A. L. and **Edwards, F. W.**
1926. Fungus-gnats of New Zealand. Trans. N. Z. Inst. 57:747-878, pls. 58-80.

Winnertz, J.
1867. Beitrag zu einer Monographie der Sciariden. K. K. Zool. bot. Gesellsch. Wien. 187 pp., figs. 1-8.

Three new Species of Eurytoma (Hymenoptera: Eurytomidae)

By D. T. FULLAWAY

The three species of *Eurytoma* described in this paper are represented by specimens in several collections in Hawaii. One, a probable hyperparasite on *Apanteles* and *Bracon,* has been known for nearly half a century (Bull. 5, Div. of Ent., Expt. Sta., Hawaiian Sugar Planters' Assoc.: 39, 1907). It seems desirable to publish descriptions of the species so that they can be readily recognized, although their host relationships are usually sufficient to identify them. The types are all in the type collection of the Hawaiian Entomological Society, Honolulu, T. H.

Eurytoma tephritidis, new species.

Female. Length 2 mm. Black, only the knees, tips of tibiae and tarsi brownish testaceous, claws black; wings hyaline, venation brownish. Head and thorax with strongly umbilicately punctate sculpture; thinly clothed with short, silvery white hairs. Antennae half length of body, attached above lower level of eyes, the groove rather wide and smoothly polished; scape reaching front ocellus, rather thin, pedicel obconic and no thicker than scape, flagellum twice as thick and more than double length of scape, although the ring-joint is very small, funicle 5-segmented, the separate segments all a little longer than wide except 5th, which is subquadrate; the 1st narrowed proximally to width of ring-joint; club 3-segmented, the separate segments closely joined without the button-like pedicel between the funicle segments, the three segments together nearly as long as funicle segments 4 plus 5, and one-half 3, the last blunt-pointed, all clothed with appressed, silvery hairs. Ocelli on vertex arranged in form of a very low triangle, the post-ocellar line more than twice the length of the ocellocular line. Occiput immargined above, cheeks margined posteriorly. Eyes small. Genae nearly as long as median width of eye, and lying almost at right angles to face, which is wider than high. Dorsal portion of pronotum very nearly as broad as mesonotum and distinctly shorter than mesoscutum, width about twice length, more or less convex, front portion declivous and displaying a slight neck. Mesoscutum with complete parapsidal furrows dividing it into three lobes, the middle one anteriorly more or less smooth. Scutellum convex with rounded posterior margin. Mesepisternum granularly rugulose, the mesepimeron indistinctly longitudinally striate. Propodeum very nearly perpendicular to apex of scutellum, broadly but very shallowly impressed medially, the impressed area granulose rugulose; remainder of propodeum more coarsely rugulose, developing blunt conical projections on posterior margin at edge of median depression. Marginal and postmarginal veins practically equal in length, the latter, however, thinner, the stigmal three-fourths as long as marginal, ending in a large knob with 4 to 5 blobs apically. Abdominal petiole very short and thick, with granular sculpture, connecting a protuberance of the propodeum and a fluted section of the 1st abdominal segment, and joining the main part of the abdomen at the antero-ventral angle. Body of abdomen short oval, ending in a sharp point, strongly compressed from sides, very strongly arched above attachment of petiole as viewed from the sides; a little longer than head and thorax combined and, viewed laterally, one-third to one-half longer than thick dorso-ventrally, 5th segment largest, approximately twice length of 4th on median dorsal line. Ovipositor slightly exposed at tip. Hind coxae with fine, reticulate sculpture, shagreened in appearance.

Male. Length 1.75 mm. Scape slightly swollen beneath, reaching to front ocellus, pedicel globose; between pedicel and 1st funicle segment, one small ring-joint; funicle 5-segmented, the segments, except 5th (although it too has a small neck) narrowed at

apex into a distinct neck, each segment about twice as long as thickness of thickened portion, or a little more, and bearing hairs a little longer than width of segment; club 2-segmented, the segments subequal in length, together about one and one-half times as long as a funicle segment. The propodeum nearly uniformly reticulately rugose all over; sculpture of depressed area not markedly different from rest of surface. Abdominal petiole a third again longer than hind coxae, smooth and shining. Body of abdomen small, seen from side, rhomboid in outline and compressed or sub-compressed; dorsal outline of 1st and 2nd segments (after pedicel) highly arched, that of segment 3 descending, 4th and following segments telescoped; 1st and 2nd ventrites and apical margin of 3rd segment forming almost a right angle; surface smooth and shining.

Described from six specimens (holotype female, allotype male and four paratypes) reared from *Procecidochares utilis* Stone galls collected on Mt. Tantalus, Honolulu, Oahu, June 2, 1948.

Eurytoma swezeyi, new species.

Female. Length 2 mm. Black, underside of flagellum dark brown, scape, tibiae, tarsi and femora apically light brown to whitish, hind tibiae somewhat fuscous on middle portion; claws brown; wings hyaline, venation brownish. Head and thorax with strong umbilicately punctate sculpture, thinly clothed with short, silvery white hairs. Antennae rather short (less than half body length) and fairly thick, attached at mid-level of eyes; composed of scape, pedicel, ring-joint, 5-segmented funicle and 3-segmented club; scape slightly swollen beneath and reaching a little beyond vertex, pedicel subglobose, a little wider than long, disregarding the narrow pedicel by which it is attached to the scape; ring-joint small, funicle segment one and one-half to twice as long as thick, 1st distinctly longer than the following, together they are twice length of scape, club as long as last two funicle segments and one-half 3rd; 2nd and 3rd indistinctly separated, gradually narrowing to a point, funicle segment and club well clothed with silvery white, appressed hairs; scrobes short and no wider than distance to eye; ocelli arranged in low triangle on vertex, basal width twice ocellocular line, face fairly flat, its plane at an angle to that of cheeks, the genae more than half width of eye in length, but narrowing to post-genae, which are carinate on outer margin. Head as wide as thorax, perhaps a little wider, and quite wide between eyes; from above, the width is double length from upper limit of scrobes to occipital margin, which is distinctly incurved. Dorsal portion of pronotum as broad as mesonotum, and distinctly shorter than mesoscutum; mesepisternum granularly rugulose, the epimeron indistinctly, longitudinally striate. Mesoscutum convex, with complete parapsidal furrows, which, however, are only indistinctly marked; axillae not quite meeting at inner angle; scutellum as long as mesoscutum and convexly rounded; propodeum declivous, not precipitously, but with gradual slope, impressed area medially broadly shallow and granularly rugulose, remainder of propodeum more coarsely rugulose. Marginal and postmarginal veins thin, practically equal, submarginal longer than postmarginal and marginal together, not reaching costal margin apically, the stigmal a little shorter than postmarginal and extending outwardly at a 30-degree angle, thickened apically and terminating in four hair follicles. Abdominal petiole short, less than one-third length of hind coxa, granularly sculptured; joining main part of abdomen at antero-ventral angle. Abdomen as long as head and thorax combined, strongly compressed from sides, short ovate, ending in a sharp point, smooth and polished; 2nd segment as long as 5th, on dorsal line and at hind margin the highest point of abdomen; 3rd and 4th segments subequal but less than three-fourths width of 5th, which is widest; 6th, 7th, 8th and 9th segments narrowing to a blunt point and lying above the stout, very thin ovipositor sheaths; 7th to 9th segments with transverse line of silvery hairs, the sheaths also clothed; ovipositor slightly exposed at tip. Hind coxae granularly rugulose like middle of propodeum.

Male. Length 2 mm. Antennae rather slender and more than half length of body, composed of scape, pedicel, ring-joint, 5-segmented funicle and 2-segmented club; scape with leaf-like expansion beneath, the ventral margin sinuate; pedicel globose, ring-joint very small, funicle segments stout, more than twice as long as wide, the separate segments, except 5th, narrowed at apex into a distinct neck and bearing a whorl of hairs

which are about as long as the segment; segments of the club not quite as long or stout as those of funicle, bearing similar hairs, the apical segment blunt-pointed. Propodeum nearly uniformly, reticulately rugose, the sculpture of depressed areas, however, not as bold as that of rest of surface. Abdominal petiole longer than hind coxae, but hardly twice as long, slender and weakly shagreened. Body of abdomen small globose, attachment of petiole at antero-ventral angle; ventral line more or less straight, but the dorsal line to posterior margin of 4th segment very strongly arched; a pair of minute protuberances marks the apex; dorsal line of 5th and following segments gradually descending to form a blunt point at ventral line; 5th segment the widest, following segments gradually narrowing, the terminal ones bearing hairs. Otherwise similar to female, but front and middle legs pale brown. In the specimen studied the penis was extruded half the length of the abdomen.

Described from numerous specimens in the collection of the Board of Agriculture and Forestry. Female holotype Ewa, Oahu, March, 1941, Q. C. Chock, reared from *Apanteles* cocoon. Male allotype, Honolulu, Oahu, June 2, 1910, D. T. Fullaway, reared from *Bracon omiodivorum* (Terry).

Eurytoma latrodecti, new species.

Female. Length 2 mm. Black, pedicel of antennae and mandibles, knees, front and middle tibiae and all tarsi testaceous; wings hyaline, venation brownish. Head and thorax with strong, umbilicately punctate sculpture and thinly clothed with short, silvery white hairs. Antennae rather short and thick (less than half the body length), attached at mid-level of eyes, composed of scape, pedicel, ring-joint, 5-segmented funicle, and 3-segmented club; scape elongate, expanded slightly beneath (lower margin sinuate), not reaching vertex, about as long as funicle segments 2, 3 and 4 combined; pedicel subglobose (no longer than wide without neck), ring-joint very small, funicle segments together about twice length of scape, the 1st one and a half times as long as wide apically, basally narrowed to width of ring-joint, four following funicle segments more or less quadrate, 2nd a trifle longer than wide, 5th a little wider than long, club as long as last two funicle segments and one-half 3rd; basal joint like 5th funicle, 2nd a little longer than wide, 3rd shorter and narrowing to a point, all segments except 1st funicle and apical segment of club with a narrow pedicel, and all well clothed with whorls of hairs about as long as width of antennal segments; scrobal cavity subcircular in outline, short and wide but not much wider than distance to eye, surface smooth and polished, upper margin not quite reaching anterior ocellus; ocelli arranged in low triangle on vertex, basal width twice length ocellocular line, anterior ocellus larger than lateral ones; face fairly flat, its plane at an angle to that of cheeks; medially below antennae a scutate smooth area, longitudinally carinate and minutely punctate on middle, on either side the surface is marked with fine striae running diagonally toward mouth; clypeocular line or groove fully as long as width of eye, and sinuate; genae and post-genae quite wide, the latter carinate on outer margin. Head as wide as thorax, eyes small, widely spaced; from above, width of frontal vertex triple the length from upper limit of scrobal cavity to distinctly incurved occipital margin. Dorsal portion of pronotum nearly as broad as mesonotum and distinctly shorter than mesoscutum; mesepisternum marked with longitudinal striae; epimeron fossulate; mesoscutum convex, with complete parapsidal furrows rather indistinctly marked; axillae small, not nearly meeting at inner angle; scutellum as long as mesoscutum and convexly rounded; propodeum precipitously declivous, its rather flat and granularly rugose median surface at right angles to apex of scutellum, remainder of propodeum more coarsely rugulose. Submarginal vein of forewings long, nearly reaching middle of wing; postmarginal only a fourth as long, but longer than marginal, which is thicker; stigmal a little more than half as long as postmarginal, extending outwardly at a 30-degree angle, expanded apically and terminating in a well-developed uncus. Abdomen subglobose, nearly as long as thorax, well rounded dorsally, ventrally somewhat compressed from sides, apically blunt-pointed, surface mostly smooth and polished, under high magnification exhibiting a microscopically fine punctuation, 6th and following segments displaying a more pronounced punctuation and clothed with silvery hairs,

rendering the surface dull; petiolar segment rather short (hardly half length of hind coxa) but longer than wide, granularly sculptured, attachment at antero-ventral angle; 2nd and 3rd segments strongly arched, posterior margin of 3rd becoming the dorsal summit; 3rd, 4th and 5th segments subequal in width, with 5th perhaps widest; from side, the dorsal line of segments 4 and 5 is nearly horizontal; ventral line curved upward; 6th and following segments somewhat telescoped, gradually narrowing to width of the pointed valves; ovipositor slightly protruding. Hind coxae granulately rugose.

Male. Length 1.75 mm. Antennae generally similar to those of female, but with 2- instead of 3-segmented club; funicle segments all longer than wide, 1st nearly twice as long as wide, club as long as last two funicle segments together, proximal segment about one and one-half times as long as wide, distal a little shorter and narrowing apically to a point; abdominal petiole longer than in female, almost as long as hind coxa; terminal segments of abdomen telescoped.

Described from numerous examples reared in Honolulu from egg cases of *Latrodectus geometricus* Koch in 1945 and 1946. Holotype female on card point with head removed and gummed on separately, Honolulu, Oahu, June, 1946, Mabel Chong, from *Latrodectus geometricus;* allotype male in H.S.P.A. Experiment Station collection, Honolulu, Oahu, May 18, 1945, Mary F. Rosa, ex egg case *L. geometricus,* wing and antennae mounted separately on slide; 6 paratype females labelled like allotype, and one like holotype.

This species has been bred also on eggs of *Latrodectus mactans* (F.). It has been compared with *Eurytoma arachnovora* Hesse from South Africa and shown to be different (Pemberton and Rosa, The Haw'n. Planters' Rec., 50:29-37, 11 figs., 1946). It may, however, be the species reared from *Latrodectus* egg cases in Australia and described by Girault as *Bruchophagus arachnophagus* (Insec. Inscit. Men., 13:99-100, 1925). Girault's description is inadequate for accurate determination, and efforts to secure material from Australia for comparison have been unsuccessful.

New Hawaiian Coniopterygidae (Neuroptera)

By D. E. KIMMINS

DEPARTMENT OF ENTOMOLOGY, BRITISH MUSEUM (NATURAL HISTORY)

The following descriptions have been prepared at the request of Elwood C. Zimmerman, to enable him to refer to the species in the sixth volume of his "INSECTS OF HAWAII."

Aleuropteryginae

Coniocompsa zimmermani, new species (figs. 1-3).

Head dark reddish brown, antennae fuscous, the two basal segments paler, ♂ 19-, ♀ 18-segmented, the segments broader in the male. Thorax dark brown, legs pale fuscous. Wings moderately waxy. Fore wing broader than in *C. japonica* Enderlein in both sexes. R_1 terminating in Sc, Rs not detached from R_1; stem of M rather sinuous. Cell M_1 slightly narrower than in *vesiculigera* but much less so than in *japonica*, the M-Cu cross-vein present. Pale brown spots on the terminations of R_1, R_{2+3}, R_{4+5}, M, Cu_1, Cu_2 and surrounding the cross-veins Sc-R_1, R_1-Rs, Rs-M, M-Cu and between M and Cu at the level of the outer setigerous spot. There is also a paler brown cloud in the disc of the wing between Sc and Rs and another at the base between Sc and R. Hind wing with the cell R_{2+3} shorter than in *vesiculigera*.

Genitalia ♂. Ninth segment with its upper portion semi-membranous, lower portion larger, more sclerotized, from beneath rather widely excised, the center of the excision produced in a pair of rounded lobes separated by an acute excision. From the side the lateral margin of the segment projects in a triangular lobe. Claspers forcipate, each divided almost to its base to form two claws. Aedeagus large, gradually tapering to an upcurved apex, from which projects a slender, transparent process. On each side of the aedeagus is a slender rod or paramere, its apex somewhat obscure.

Length of fore wing ♂ ♀ 2.3 mm.

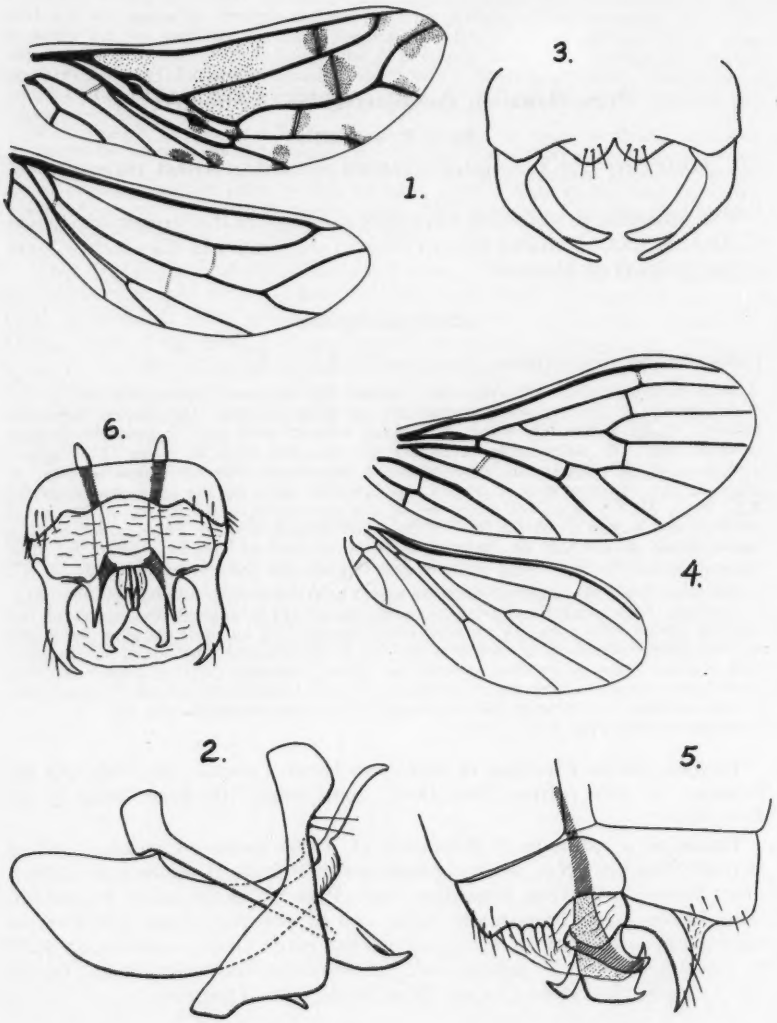
Hawaii: Oahu, flats west of Makapuu Head, February 11, 1934 (O. H. Swezey), on wild cotton: Ewa, Oahu, light traps, May-June, 1952 (C. E. Pemberton).

Holotype ♂, allotype ♀ (February 11, 1934) gummed on one card in British Museum (Nat. Hist.); paratypes in British Museum and Experiment Station collection, Hawaiian Sugar Planters' Association, Honolulu. The figures have been made from one of the paratypes, mounted as microscope preparations. Comparisons are given in the description with *C. vesiculigera* and *C. japonica*. *C. zimmermani* also resembles *C. indica* Withycombe, but differs in the form of the male claspers.

Coniopteryginae

Coniopteryx pembertoni, new species (figs. 4-6).

Head dark fulvous, antennae fuscous, rather stout, 26-segmented. Meso- and metanota dark fulvous with a round piceous spot above the base of each wing. Legs pale fuscous, abdomen yellowish. Wings typical of the genus, venation as figured.



Figures 1-3. Coniocompsa zimmermani, new species, ♂. **1,** wings; **2,** ninth segment, claspers, parameres and aedeagus from side; **3,** ninth sternite and claspers, ventral.

Figures 4-6. Coniopteryx pembertoni, new species, ♂. **4,** wings; **5,** genitalia from side; **6,** genitalia, ventral.

Genitalia ♂. Hypandrium with an irregularly serrate apical margin. Claspers acute and falcate; from the side with the lower margin produced in an acute tooth to which is attached a narrow, chitinous band passing beneath the parameres and aedeagus. Paramere with a long stem and a thin plate-like apex, set on edge, its outer surface convex and with its upper margin bearing two recurved claws, the apical one being also incurved. Aedeagus situated between the apices of the parameres, formed of two plates set on edge, their apices hooked downwards.

Length of forewing 1.7 mm.

Hawaii: Oahu, Ewa, February 4, 1952, light trap (C. E. Pemberton) 3♂, 2♀.

Holotype ♂ (February 4, 1952) mounted as a microscope preparation in British Museum (Nat. Hist.); paratypes in collection of the Experiment Station, Hawaiian Sugar Planters' Association, Honolulu. This species belongs to the *maculithorax* group. It may be distinguished from *C. ralumensis* Enderlein (Bismarck Archipelago) and *C. javanica* Enderlein (Java) by the presence of a cross-vein between M and Cu_1 in the hind wing. *C. maculithorax* Enderlein (Australia) was described from a single female; the Hawaiian species is closely related to it but differs in the position of the cross-vein between R_{4+5} and M_{1+2}, and that between Cu_1 and Cu_2. Enderlein's figure (Zool. Jahrb., Syst., 23, pl. 4, fig. 5, 1906) also shows a cross-vein between Cu_2 and 1A, which is lacking in the Hawaiian species. It is possible that these differences are not specific, but in the absence of information concerning the male of *maculithorax* it seems preferable to treat them as distinct.

Observations on the Stem Gall Fly of Pamakani, Eupatorium glandulosum

By ALAN P. DODD

The tephritid fly, *Procecidochares utilis* Stone[1], was introduced into the Hawaiian Islands from Mexico in 1945, to breed upon *Eupatorium glandulosum* (syn. *E. adenophorum*), the plant (family Compositae) known locally as "pamakani." It is now established on the islands of Oahu, Molokai, Lanai and Maui,[1a] where it is confined to the single host-plant species for which it was introduced. Growing sometimes in close association with the closely related *Eupatorium riparium*, of similar habit, true pamakani is commonly infested with the conspicuous galls formed by the fly larvae, whereas *E. riparium* has never shown any indication of attack.

During the period from November, 1951 to January 1952, on behalf of the Commonwealth of Australia, a study was made of the reaction of *P. utilis* to plants other than pamakani. Comprehensive tests in wire screen cylindrical cages with various growing plants confirmed earlier observations made in the field in Mexico, and in the Territory of Hawaii, that this insect is truly monophagous. As a result, consignments of adult flies were forwarded to Australia during February, 1952. These tests resulted in the following observations on the life history and habits of the fly, which are presented as a matter of interest and record.

Life History and Habits

Adult activities such as emergence, copulation and oviposition, take place during daylight hours. In general, emergence takes place before 11 a.m., but this may vary in dull weather. The flies are not long-lived. The majority survived for about 8 to 12 days, with a recorded maximum of 26 days; survival for 20 days was not common.

Oviposition begins within 24 hours after emergence and continues for some days. Most females completed egg-laying within 7 days, although living for several days longer. The maximum observed oviposition period terminated 13 days after emergence of the female. The females do not require food for either oviposition or survival. In every experiment, unfed females deposited fertile eggs freely and continued to oviposit for the normal period. In concurrent cage tests no marked differences were noted between the ovipositional behavior and survival period of unfed flies and of those fed with honey; the maximum longevity was 17 days. Apparently, the hostplant has a strong attraction for the flies. Whenever flies not more than 24 hours old were placed in cages over pamakani plants, females were seen ovipositing within 5 minutes; this behavior was constant in all experiments.

[1] Described in these "PROCEEDINGS" 13:97-98, 1947.

[1a] Since the above was written, this gall fly has been found also on the island of Hawaii on *E. glandulosum*. See p. 12 of this issue of the "PROCEEDINGS."

The eggs are invariably laid on the growing point, covered by the terminal pair of developing leaves and usually immediately above the base of these leaves. They are not inserted in the plant tissue. However, in order to reach the base or side of the growing point the ovipositor may be forced through the blade of the young leaf. Normally, a female deposits several eggs in one place and the act requires from 15 to 30 minutes. The incubation period in December was 4 to 5 days. After eclosion the egg shells remain attached to the plants for some time (in the screen cages for not less than three weeks).

Since the eggs are not laid internally, the growing point is not injured by oviposition; normally it continues to develop. In cages where oviposition continued for several days, the growth of the stem permitted females to deposit a second batch of eggs above the next pair of leaves as they were produced. Thus, not infrequently, galls developed around two pairs of leaves separated by one or more inches of unaffected stem. The galls become apparent about two weeks (12 to 16 days) after oviposition, or about 8 to 12 days after the eggs have hatched. Individual galls may contain from one to several larvae, the usual number being 3 to 5. Pupation takes place within the galls. Before pupation each larva makes a channel to, but not through, the epidermis, thus forming a covered "window" which is broken by the emerging adult. The number of pupae within a gall can usually be determined by a count of the "windows." Before the life cycle is completed, the stem may have increased in length by three to several inches, with three or four pairs of leaves above the gall.

The minimum life cycle at Honolulu during the November-January period was 42 days for a male, and 43 for a female. Identical or almost identical figures were recorded in several cases. However, the length of the life cycle is irregular under identical climatic and environmental conditions. The following results from cage tests illustrate this point:

Cage 1. Eggs deposited November 14. Three galls developed.

Gall	No. of Pupae	Emergence	Life Cycle
A	1	1 male, January 13	60 days
B	6	3 males, 1 female, January 16	63 "
		1 female, January 17	64 "
		1 male, January 18	65 "
		1 male, 2 females, January 28	75 "

Cage 2. Eggs deposited November 27. Five galls developed.

Gall	No. of Pupae	Emergence	Life Cycle
A	3	2 males, January 9	43 days
		1 female, January 11	45 "
B	1	1 male, January 21	55 "
C	1	1 male, January 27	61 "
D	1	1 female, January 27	61 "
E	5	2 males, January 27	61 "
		1 female, January 29	63 "
		1 female, January 30	64 "
		1 female, January 31	65 "

The adults are tolerant of moderately low temperatures. Flies less than 24 hours old were kept in a small wooden mailing box at 40 to 42 degrees F. for four days. All survived and became active immediately after removal to room temperature. After 40 minutes they were placed in cages with pamakani plants, and within 15 minutes females were ovipositing.

Behavior Toward Other Plants

Approximately 5,000 flies were used in testing oviposition on 56 different kinds of plants including cereals, vegetables, agricultural crops, fruit trees, ornamentals and shade trees. Eleven composites were used, since *Eupatorium* belongs to this family. Ten to 12 pairs of flies, none over 24 hours old, were caged with each plant, and each test had three replicates. The flies lived as long, or almost as long, in the test cages as in the controls with pamakani plants. With two exceptions (both composites) the flies showed a complete lack of interest in the given plant, failed to recognize it as a potential host, and died without ovipositing.

The two exceptions were *Eupatorium riparium* and *Ageratum,* a genus closely related to *Eupatorium. Eupatorium riparium,* sometimes called "dwarf pamakani" or "Hilo pamakani," is similar to *E. glandulosum* but smaller. Six experiments were carried out with *E. riparium.* Eggs were laid freely on the growing points, and oviposition continued for several days. There is no doubt that the eggs hatched, but no larvae developed and no gall formation occurred. The plants, examined a month after the start of the experiments, showed many hatched eggs. Often there were surface scars or injuries on the young leaves. In a few instances there were small sections of dead tissue on or near the growing point, suggesting that young larvae succeeded in penetrating the tissue; as no larvae could be found in these situations, they must have died soon after hatching. In view of the close relationship and similar growth habits of true pamakani and *E. riparium,* the failure of the larvae to develop on the latter seems to have particular significance and suggests a high degree of host specificity.

Four experiments were conducted with *Ageratum.* For the first two days the flies were definitely attracted to the plant. Females were frequently observed examining the terminal growth, and one female was seen to oviposit. But from the third day onward until they died, after a maximum life of 18 to 20 days, the flies showed no interest in the plants. Subsequent examination resulted in finding three small lots of hatched eggs on one plant, but no sign of larval development or growth injury.

Parasitism

A small lot of galls collected in December on Mt. Tantalus, Oahu, produced 57 gall flies and 86 parasites, a parasitism of 60 per cent. Two parasites were represented; 53 examples of *Eurytoma* sp.[2] and 33 of *Opius tryoni* Cameron. It should be noted that *Bracon terryi* (Bridwell), the

[2] This is the species described by Fullaway as *Eurytoma tephritidis* on p. 33 of this issue of the "PROCEEDINGS."

dominant species in the (lowland) Honouliuli, Oahu, area was not found in this Tantalus material. The comparatively large number of *O. tryoni* is of interest. This insect has been established in the Territory for many years as an enemy of *Ceratitis capitata* (Wiedemann) and had been bred previously from *Procecidochares* from the Tantalus area.

From one lot of galls collected at Honouliuli on the southeast slope of the Waianae Range early in December, 1,090 gall flies and 220 parasites emerged. Assuming one parasite per host larva or pupa, this gives a degree of parasitism of 16.8 per cent. However, since nothing is known of the life history of the parasites in relation to the host, records of this type are merely indicative, not exact. The three parasites reared were those which have previously been obtained from *P. utilis* on Oahu and Maui, i.e., *Bracon terryi, Eurytoma* sp., and *Eupelmus cushmani* (Crawford). *Bracon* was the dominant species with 177 *Bracon,* 28 *Eurytoma* and 15 *Eupelmus.* The peak of emergence of *Bracon* was approximately one week earlier than that of the host. The other two parasites mostly emerged simultaneously with, or a few days after, the last host emergence.

Further material from the Honouliuli area collected in late January (emergence of flies and parasites had not been completed as this was written) produced at least 12 *Opius tryoni.* It is of interest to note that this parasite was not reared from material collected in the same area from November to December. Incidentally, the number of *Bracon terryi* emerging from the late January galls is definitely lower than that from the November-December material.

Notes on some Dragonflies (Odonata) of the Cook Islands

By M. A. LIEFTINCK

DIRECTOR, MUSEUM ZOOLOGICUM, BOGOR, JAVA

Since many islands in the Pacific have still remained unexplored as far as dragonflies are concerned, it seems worth while to put on record the results of collecting in any part of this vast area where little work on the order has been done. The present short account deals with a small collection of these insects recently brought from Rarotonga Island.

General information[1]

The Cook group (excluding Niue Island) comprises fifteen islands. These are generally small and are widely scattered throughout an area of some 850,000 square miles of ocean extending from 9° to almost 23° south and from 156° to 167° west, the total land area being approximately 100 square miles. With the exception of Niue, the islands fall naturally into two distinct areas—the southern or lower group, and the northern group. The lower group consists of eight islands, of which Rarotonga, Aitutaki, Atiu, Mitiaro, Mauke, and Mangaia are permanently settled. The two largest islands are Mangaia (17,500 acres) and Rarotonga (16,500 acres), all other islands occupying an area of less than 5,000 acres. The northern group consists of seven small islands, of which five—Penrhyn, Manihiki, Rakahanga, Pukapuka, and Palmerston—are continuously inhabited, and Suwarrow and Nassau. Except for a weather station on Suwarrow, neither of these islands is normally inhabited.

Rarotonga, the seat of the administration, is 1,633 nautical miles from Auckland and lies in latitude 21° 12′ 04″ south and longitude 159° 46′ 33″ west.

With the exception of Manuae, which is a coral atoll, the lower group islands are of volcanic origin, having a hilly or mountainous interior surrounded by fertile lowlands. The height of the interior varies up to an elevation of 2,140 ft. All the islands are surrounded by a coral reef. Most have in addition an elevated coral reef—known locally as the "makatea"—which encircles the islands almost immediately behind the coast-line. The soil of the lower group is very fertile and is suitable for the cultivation of the usual tropical and subtropical products. The islands of the northern group are typical coral atolls; the soil of the majority of these islands is poor, being largely coral sand. Coconut palms thrive, but there is some shortage of other food crops.

All these islands lie within the hurricane belt. Hurricane damage occurs in some parts of the group roughly once every two years. Within recent years the most destructive storms have occurred in 1935, 1943 and 1946.

[1] The following informative notes are taken from the Annual Report, March 1950, on the Administration of the Cook Islands, Dept. of Island Territories, Wellington, N.Z., A-3, 48 pp., 1950.

The climate of the lower group is mild and equable, except in the summer months. At Rarotonga the mean annual temperature is 74.5°. February, the warmest month, has a mean temperature of 78.6°, while July and August are the coolest months, both with a mean temperature of 70.8°. The average annual rainfall is 84 in. In the lower group the rainfall is adequate and there is little danger of serious drought. In the northern group, however, the problem of water-supply is acute.

According to the traditional history of Rarotonga, the island was settled by Karika from Samoa, and Tangiia from Tahiti. The two warriors are said to have met at sea and, joining forces, landed on Rarotonga an estimated twenty-six generations ago.

The European discovery of Mangaia, Aitutaki, Atiu, Takutea, Mitiaro, and Manuae was made by Captain Cook in 1773 during his second voyage of discovery. Rarotonga and Mauke were not discovered for another fifty years, when the Rev. John Williams successfully located them from information supplied to him in Aitutaki and other adjacent islands.

The Cook Islands Maori is a Polynesian and is closely related to the New Zealand Maori. There is a strong resemblance between these two peoples in tradition, language, and custom. Many of the tribes in both places are able to trace their descent back to a common ancestor.

Note on the odonate fauna

Except the reported occurrence of *Ischnura a. aurora* (Brauer) on Pukapuka I. (Lieftinck "Nova Guinea," n.s., 5:222, 1949), the dragonflies of the remote Cook Islands are entirely unknown. During the latter part of 1950 and the first months of 1951 I received two small collections of these insects from Lindsay Rollo, at that time a resident of the Cook Islands and technical officer at the Ionosphere Observatory on Rarotonga. Although nothing new or particularly interesting has yet been discovered, I am grateful for Mr. Rollo's keen interest and activity in bringing together this collection which will, I hope, stimulate others to explore the islands more thoroughly than he was able to do. The number of species represented is very limited and leads one to conjecture that when collecting has been carried out further afield several more species will come to light; but considering the small size and comparatively recent origin of the islands, endemic genera and species—if any—are probably absent or only few in number. With the possible exception of *Tramea* spp., which may be confined to parts of the central Pacific, all species found are unquestionably recent immigrants which have spread to these islands through the air and have a wide distribution, some extending far into the Oriental and Australian regions. What makes this report worth publishing are Mr. Rollo's notes on the habits and breeding places of the species encountered by him on Rarotonga. These remarks are quoted from his letters and put between quotation marks.

I have taken the present opportunity to list a few specimens collected in 1933 on Pukapuka I., by members of the Templeton-Crocker Expedition, which are now in the Science Museum, California Academy of Sciences, San Francisco.

Sub-order Zygoptera

Fam. Coenagriidae

1. **Ischnura a. aurora** (Brauer).—A series of both sexes, Rarotonga I.

"Practically all were taken in the upper reaches of the mountain valleys near small streamlets and around the taro swamps. They do not appear to favour the more open places in the valleys, or the area near the ocean shore, although adult females were occasionally seen beside the creeks near the sea. Occurs all the year 'round and is commonest where the vegetation is low and tends to cover the edge of the water. The streamlets at which it was seen are usually running fairly swiftly. Never seen ovipositing." All females caught are heterochromatic.

Distribution.—A wind-blown species, ranging from India to New Zealand and the central Pacific. One distinct subspecies in the central mountain range of New Guinea (see: Lieftinck, "Nova Guinea," n.s., 5:220-223, figs., 1949).

Sub-order Anisoptera

Fam. Aeshnidae

2. **Anaciaeschna jaspidea** (Burmeister).—1 ♂, 3 ♀, Rarotonga.

"Not a common species on Rarotonga, but there are a few all the year 'round. They hawk along the small streams near the shore and often along hedges inland. About January till March I noticed that they were often to be found near the station I was working at, and this was about a mile from the sea, well up a valley. It breeds on the island, and the ♀ lays the eggs on damp shady banks and on wet vegetable matter above water-level in the creeks, but never in the water itself. One ♀ specimen brought in by a resident from another part of the island, who informed me that it appeared with a large number of the same species, hovering over the beach inside the lagoon. The others were taken by myself in January to February, 1951."

Distribution.—From India eastwards to the Loo Choo Islands, and throughout the Indo-Australian archipelago into the Pacific as far as Tahiti.

3. **Anax guttatus** (Burmeister).—1 ♀ Rarotonga.

This specimen, the only one noticed, was captured in February, 1951, along with the examples of *A. jaspidea.*

Distribution.—From India through the Malay archipelago to the Pacific as far east as the Tuamotu Islands and northern Australia.

Fam. Libellulidae

4. **Diplacodes bipunctata** (Brauer).—A series of both sexes, Rarotonga. 3 ♀, Pukapuka I., April 19, 1933, M. Willows Jr.

"Not as common as *Pantala* but could be taken without much trouble. Prefers open areas in the lower reaches of the valleys, often away from

water, along roads, etc. Most common during our winter (May-Oct. approx.). I have often watched the red-bodied males actively hawking up and down a fairly well defined stretch of a small creek at the bank of the hotel where I lived. It patrols about 10-12 yards only and turns at almost the same point at each end of its beat regularly. Several times I have seen it chase away another male, then return to its patrol. *Pantala* was never noticed along this creek."

Distribution.—Possibly of Australian origin, distributed all over the Pacific, increasingly more common from the eastern Lesser Sunda Islands and the Moluccas towards the east.

5. **Tholymis tillarga** (F.).—A small series of both sexes, Rarotonga.

"Common in the tidal areas of the small creek at the back of the hotel Rarotonga, and never seen anywhere else. This species has only appeared in the last month, *i.e.*, November-December, 1950. Mating takes place on the wing, and the ♀ starts egg-laying immediately after copulation, with the ♂ still in attendance. If another ♂ enters onto the mated pair's territory, it is chased off and often the ♀ flies away. I have not been able to see if it continues to oviposit elsewhere immediately. Eggs are laid among grass stalks and other floating material in the stream."

Distribution.—Tropics of the Old World; wide-ranging and chiefly littoral. Flies chiefly at dusk, low and very swiftly, over open water.

6. **Pantala flavescens** (F.).—A series of both sexes, Rarotonga. 1 ♂, Pukapuka I., April 9, 1933, M. Willows Jr.

"Certainly the most common species, found all around the island in fairly constant numbers at all times of the year. They seem, generally, to be more common a short way up the valleys than near the seashore. Female lays eggs whilst in flight, in taro swamps etc."

Distribution.—Almost cosmopolitan, throughout the tropics and warmer temperate countries.

7. **Tramea** sp. indet.—1 ♀, Rarotonga, April 19, 1950.

"Caught by one of my native operators and the only specimen ever seen."

This example, though immature, is in good condition. Unfortunately, by the absence of a ♂, it is impossible to identify it with any degree of certainty. Judging from the shape and length of the genital valves, it is definitely not *löwii tillyardi* Lieftinck, from Australia and a few surrounding island groups, but is either a member of the group *euryale* Selys or belongs to the "formenkreis" *eurybia* Selys. Solitary females of these two species groups are often very difficult to separate. Since *T. transmarina* Brauer, from Fiji and Samoa, is undoubtedly the same insect as *euryale*,[2] both being characterized by having the basal spot on the posterior wing greatly reduced in size, the present large-spotted individual most likely can be linked with *eurybia*, which is known to occur as far

[2] The synonymy of these species will be discussed in a forthcoming paper on Micronesian Odonata.

east as the Solomons, but here again without knowledge of the ♂ it would be most unwise to do so at present.

♀.—Anterior surface of head dirty yellowish brown, the labrum very dark brown. Frons with a thick dark basal stripe, running half-way down along the eye-margin and tapering laterally, brilliant metallic-blue above; vertex brown with low metallic lustre. Thorax dull brown, the sutural stripes blackish. Legs, except the coxae and trochanters, wholly black. Wings hyaline; anterior pair unmarked save for a minute yellow basal point in *cu;* posterior wings with ill-defined yellow basal spot in *c-sc* and a large, irregular, opaque red-brown patch extending across wing from *Cu* to tornal angle: in *cu* as far as mid-way between *Cux* and *t,* almost two cells between *Cu* and A_2 before triangle, then back behind A_2 extending 6 cells into the anal loop between A_2 and A_3, and then bending away under a right angle and in a convex curve towards the tornal margin, nearly touching the anal border of wing. This basal mark, however, is deeply and conspicuously indented by a very large hyaline marginal fenestra beyond *mb,* extending from distal four-fifth of *mb* analwards along basal margin for about 5 mm., invading the dark patch distad for almost 4 mm. before reaching the vein A_3, the brown isthmus of the basal patch at that point being only 1½ mm. (2 cells) wide. No definite golden-yellow areola. Pterostigma yellow.

Abdomen red, segments unmarked dorsally, except 8-10 which are black above, the band on 8 tapering anteriorly to a point that touches the base of segment. Valvula vulvae with the lobes slightly divaricate, equal in length to 9th tergite, very similar in shape to those of *euryale* Selys and *propinqua* Lieftinck. Anal appendages incomplete.

Measurements: abd. (without appendages) 30.0, hind wing 44.0, pterostigma fore wing 3.0 mm.

The Larva of Morion and its systematic Position (Coleoptera: Carabidae)

By F. I. VAN EMDEN

LONDON

Dr. J. L. Gressitt of the U. S. National Research Council has recently submitted a single carabid larva from the Palau Islands, which, because of its size, he could only refer to *Pseudozaena tricostata tenebrosa* Sloane, or to *Morion orientalis* Dejean, the species identification of the adult of the latter being somewhat uncertain. The specimen was found at Ngiwal, Babelthuap Is., Palau Islands, November 7, 1951, "fed on *Oryctes* larva" (J. L. Gressitt). In my key (1942, Trans. Roy. ent. Soc., 92.27) this larva is traced to *Scarites* "subg. *Distichus?*", but no species of the subtribe Scaritina or any other larger species of Scaritini has been found in the Pacific islands. The specimen on which my interpretation of the subgenus *Distichus* was based, was found associated with *Morion georgiae* (Palisot) and was at first regarded as that species. There were "however, too many deviations from typical Pterostichini (absence of antennal appendage, of mandibular penicillus, immarginate, complete abdominal tergites, slightly unequal claws)" (l.c.: 60). In spite of the fact that the specimen occurred under loose bark and together with a *Morion*, it was considered to be so typical of Scaritini and so atypical of Pterostichini that it was placed in the former tribe. Dr. Gressitt's find seems to indicate that my identification was wrong and that the specimen, which is extremely similar to the one collected by Gressitt, belongs to *Morion*.

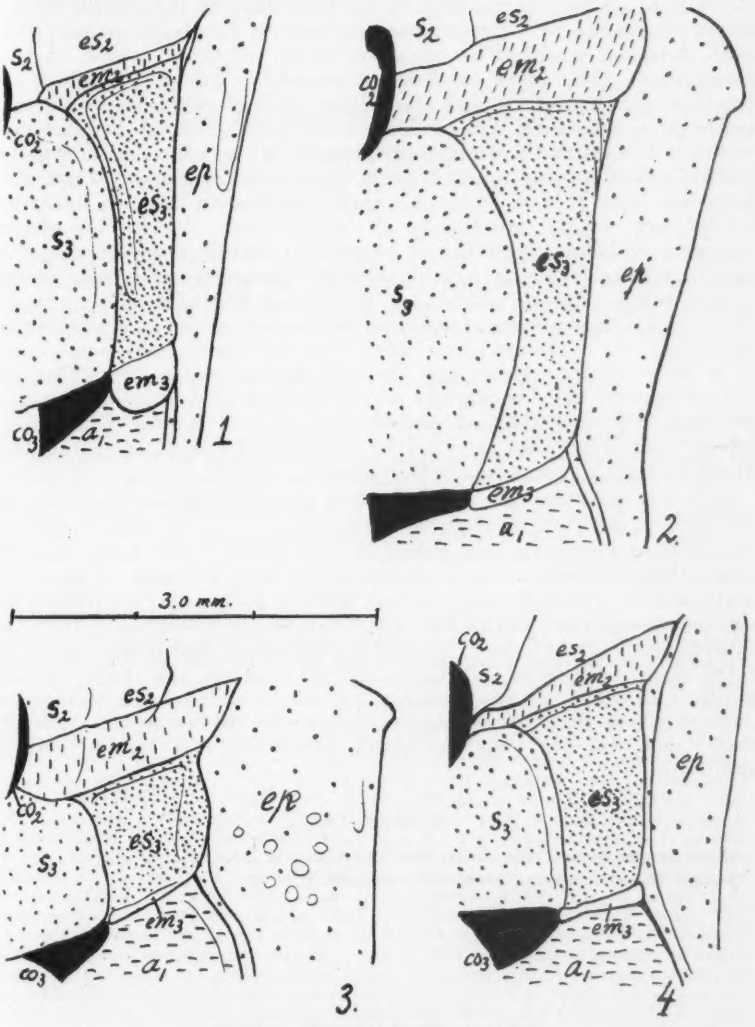
The presumed larva of *M. orientalis* Dej. differs from that of *M. georgiae* (Pal.) by the following characters: posterior claw of each tarsus much shorter, this claw being hardly half as long as the anterior one, whilst in *georgiae* it is only slightly shorter; head capsule conspicuously constricted at hind border (in *georgiae* hardly constricted), lateral keel of head reaching cervical furrow (in *georgiae* not reaching it), ventral furrow along middle of each epicranial half vestigial, shallow, present only on intermediate third (in *georgiae* deep, running from fore margin almost to hind end); first segment of maxillary palpi distinctly shorter than second (in *georgiae* of equal length); second segment of labial palpi a third length of first (in *georgiae* more than one-half); cerci longer than head capsule, strongly nodose and only moderately converging at apex (in *georgiae* more evenly rounded on inner surface, very strongly converging at apex).

The *Morion* larvae differ from the larvae of Clivinina by two claws, absence of an appendage from third antennal segment, subequal antennal segments 1-3, shorter first segment of maxillary palpi, nodose cerci, complete sclerites, etc. From the Scaritina and Pasimachina, with which they tally in possessing two claws, complete sclerites, no antennal appendage and nodose cerci, they can be distinguished by undivided epipleurites

and by the apical part (*circa* one-third) of the maxillary stipes being divided from the basal part by a membranous band (both characters as in Pterostichina). Other important characters are the presence of a small maxillary inner lobe, the complete absence of the ligula, the apex of the prementum being triangularly excised, second antennal segment not longer than first and slightly shorter than third, the latter with one large flat sensorium, nasale very broadly and rather strongly emarginate all over its width, only two ocelli, the anterior large and the posterior one small.

The identification of the larva as Morionina (Pterostichini, Harpalinae) raises a difficult and interesting problem: Is the relationship between *Morion* and *Scarites,* which most authors have placed in different subfamilies, real and due to their phylogeny, or only apparent and perhaps due to convergence? True, the definition of the larval Scaritini from Harpalinae (l.c. p. 16) is somewhat precarious, and as I said (l.c. p. 7) "the weak spot in the . . . classification of larvae is the subfamily Carabinae, for which no common character has yet been found . . ." A character discovered by Schiödte, however, is common to all larvae of Carabinae, including Ozaenini and "Paussidae" but excluding Scaritini; this is the insertion of the antennae outwards of and behind the mandibles, whilst in Scaritini and Harpalinae they are inserted above and only very slightly, behind, and at most very slightly outward of, the mandibles. In the former groups the antennae are normally directed forward and outward and the mandibles show at most a very slight dorsal impression into which the antennae fit. In Scaritini and Harpalinae the antennae are directed forward and the dorsum of the mandible is usually more conspicuously excavated where the antennae come to rest. However, the character is sometimes not quite easily judged and, moreover, the condition found in Carabinae occurs in certain Harpalinae (*e.g.* Licinini, Panagaeini, Dryptini). For these reasons I have not used it in 1942 and only to a small extent in 1919. Jeannel (1941) used a character which is probably somewhat correlated with the position of the antenna, the articulation of the mandible. However, in many larvae of *Carabus* and *Nebria,* etc., the dorsal articulation is quite as exposed as in *Broscus* and *Pterostichus,* so this character does not produce clearly defined groups. Similarly, the second important character mentioned by Jeannel, the setulose tarsus of Carabinae excluding Scaritini, is found in some Harpalinae (*e.g.* Panagaeini, Dryptini, many Chlaeniini) and does not apply to several tribes of Carabinae (*e.g.* Omophronini, Elaphrini, Notiophilini). It will thus be quite as difficult to define the larvae of Carabinae minus Scaritini from Harpalinae plus Scaritini as to define those of Carabinae from those of Harpalinae, and none of the known characters proves that larval Scaritini are more closely related to the Harpalinae than to the Carabinae.

In the adult stage Carabinae and Harpalinae, as used above, have been separated since George Horn (1881) by the formation of the mid coxae. Jeannel (1941), however, evolved a new classification, which has special importance for the position of the Scaritini. After separating Ozaenini



EXPLANATION OF THE FIGURES

These were made with a camera lucida and a Zeiss binocular microscope with eyepieces 2 and objectives a_0. They show the underside of the meso- and metathorax and base of abdomen of adult Carabidae. a_1, first abdominal segment. *s*, sternum. *es*, episternum. *em*, epimerum. *ep*, epipleurum of elytra. *co*, coxa. $_2$ stands for meso- and $_3$ for meta-.

1. *Morion simplex* Dej. 2. *Scarites anthracinus* Dej. 3. *Pasimachus cordicollis* Chaud. 4. *Blethisa multipunctata* L.

+ Paussini he divided the bulk of the Carabidae by the absence or indistinct development ("Caraboidea Simplicia" = Carabinae except Ozaenini, Paussini, Scaritini) or presence, in the shape of a lobe, of the metaepimera. The latter condition is found, according to Jeannel, in Scaritini (his Scrobifera) and Harpalinae. This classification would certainly go at least some way to explain the great similarity between the larvae of *Morion* and *Scarites*. Unfortunately, all my efforts at confirming Jeannel's classification proved entirely unsuccessful. I discovered that the harpaline genus *Morion* has (as it should according to Jeannel) lobiform metepimera (fig. 1), but that in all Scaritini these sclerites are either very narrow, band-shaped (fig. 2) or entirely undefined and represented only by a callosity (fig. 3), a result at which Bänninger arrived also (1949, Mitt. Münch. ent. Ges. **39**:155). In certain Harpalinae (*e.g.* many Broscini) the metepimera are no more developed, and in such Carabinae as *Blethisa* (fig. 4), *Lorocera*, etc., they are as well defined and conspicuous as in those Scaritini which have the most distinct metepimera. Thus in the adult stage, too, the Scaritini are widely separated from the Morionina, and, as far as the known characters go, they do not form a separate group "Scrobifera" and can only be classified in Carabinae, whilst the Morionina are in every regard Harpalinae.

There is therefore no evidence of a genuine relationship between Morionina and Scaritini, and the similarities must be either accidental or caused by convergence. The habits of both groups differ from those of most other Carabidae in so far as the insects here discussed do not normally wander above ground but force their way through obstructions in narrow passages, the Morionina under bark, and the Scaritini in the soil. Both habitats would seem to account for the strong integument, parallel-sided shape, large head and mandibles and, possibly, the "waist" of the adults. The Scaritini, quite naturally, are more cylindrical, the Morionina more flattened. Perhaps the complete sclerites of the larvae, the shape of their head and the long but strong mandibles may be interpreted similarly.

REFERENCES

Horn, George. 1881. Trans. Amer. Ent. Soc., 9, 1881-82: 91.

Jeannel, R. 1941. Faune de France, 39, Carabidae 1: 78.

New Hawaiian Tipulidae (Diptera)[1]

By D. ELMO HARDY[2]

UNIVERSITY OF HAWAII, COLLEGE OF AGRICULTURE,
AGRICULTURAL EXPERIMENT STATION

The following apparently new species were discovered while revising the Hawaiian Tipulidae for the Diptera portions of "INSECTS OF HAWAII." It is desirable that they be described at this time so that the names will be available for use in the first volume of the Diptera studies.

Limonia (Dicranomyia) iniquispina new species. Figs. 1a-c

This species is closely related to *L. (Dicranomyia) grimshawi* (Alexander) and is best differentiated by the male genital characters. The most striking differences are in the development of the spines on the rostral prolongations of the ventral dististyli. In *grimshawi* two very strong spines are developed and the distal spine is the stronger of the two (fig. 2). In *iniquispina* only a rudiment of the distal spine is present and the secondary spine is three-fourths to four-fifths as long as the rostral prolongation (fig. 1b); in *grimshawi* the second spine is about one-half as long as the prolongation. The hind margin of the ninth tergum is distinctly pointed on each side in *iniquispina* (fig. 1c), not rounded as in *grimshawi*. The ventromesal lobes of the basistyli are also more attenuated at the apex in *iniquispina*.

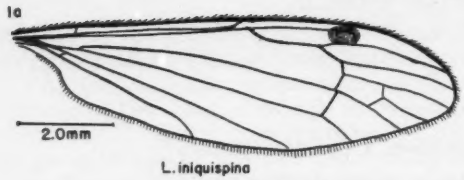
Male. *Head:* Predominantly yellow, the palpi and the labellum are brownish. The rostrum is approximately equal in length to that portion of the head behind the compound eyes. The antennae are predominantly brown; the second segment is yellowish. *Thorax:* Chiefly yellow to rufous, sometimes faintly discolored with brown. The entire thorax is rather densely covered with yellowish gray pollen. The halteres are yellow except for brownish discoloration on the stems. *Legs:* Entirely yellow except for broad bands of black at the apices of the tarsi. *Wings:* Faintly infuscated; the stigma is pale brown in color. Vein Sc_1 ends just before the forking of the radius. Sc_2 enters the costa before the forking off of vein R_2 and is not in direct alignment with it. The radial sector is about two times longer than the basal section of vein R_{4+5}. The r-m crossvein is about equal in length to the m crossvein. Cell 1st M_2 is conspicuously short, it is about equal to or slightly shorter than vein M_4. The m-cu crossvein is at or very near the forking of the median vein (fig. 1a). *Abdomen:* About one and one-half times longer than the combined lengths of the head and thorax; predominantly brown on the dorsum with the apical halves of the terga yellowish. The sterna and almost all of segments 7 and 8 are yellow; sterna 4 and 5 are brownish on their basal halves. The hairs on the dorsal and lateral portions of the abdomen are predominantly brownish to black; those of the venter are yellow. *Genitalia:* The ninth tergum is yellow to rufous except for the apical margins which are black; the aedeagus and its accessory structures are yellow; the genitalia are otherwise yellow-brown to black in color. The ventral dististyli are shorter in length than the basistyli and the rostral prolongation is about equal in length to the remainder of the dististyle. The strong spine is located at about the middle of the dorsal surface of the prolongation (fig. 1b). Genitalia otherwise as described above and as shown in figures 1b and 1c.

Length: Body, 6.0-7.0 mm.; wings, 8.0-9.0 mm.

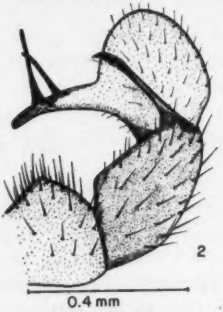
Female. Fitting the description of the male except for genital characters.

[1] Published with the approval of the Director of the Hawaii Agricultural Experiment Station as Technical Paper No. 269.

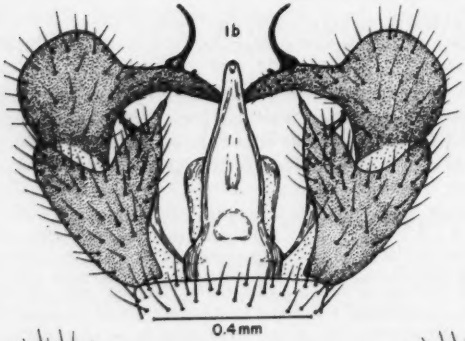
[2] The drawings were made by Marian Adachi, University of Hawaii.



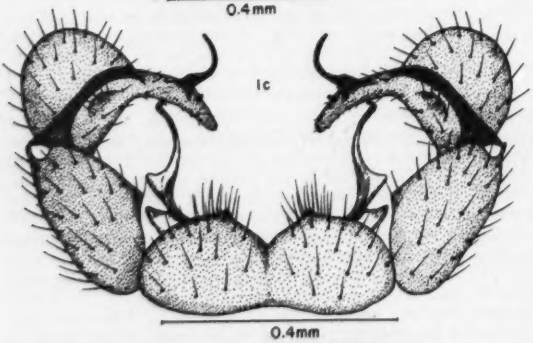
L. iniquispina

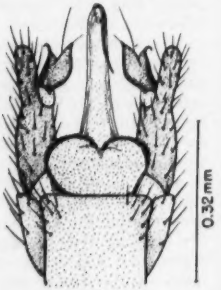


L. grimshawi

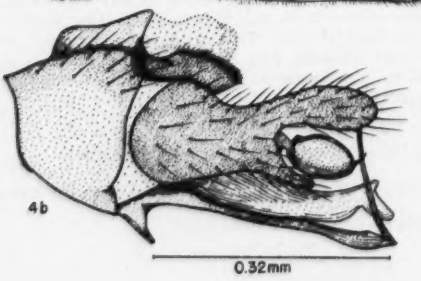


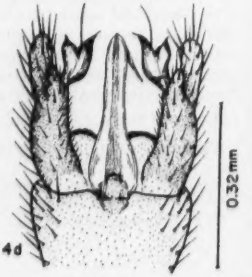
G. hawaiiensis





G. molokaiensis 4c





Holotype male, Puu Kolekole, Molokai, 4,000 ft. elev., (21° 6′ N., 156° 54′ W.), July, 1952 (M. Tamashiro). Allotype female and 11 paratypes, 10 females and 1 male, same data as type (D. E. Hardy and M. Tamashiro). Also 32 paratypes, 24 males and 8 females from the following localities: Wailau Valley, Molokai, July, 1952 (Ed. Dresner); Manawainui Valley, Molokai, July, 1952 (D. E. Hardy and M. Tamashiro); and Paliku, Haleakala Crater, Maui, elev. 6,400 ft., July, 1952 (D. E. Hardy and M. Tamashiro). The specimens were all taken in dense vegetation in very humid habitats.

The holotype, allotype, and a series of paratypes are being deposited in the United States National Museum. The remaining paratypes are being placed in the following collections: B. P. Bishop Museum, Hawaiian Sugar Planters' Association, C. P. Alexander collection, British Museum (Natural History), and the University of Hawaii.

Gonomyia (Lipophleps) molokaiensis new species. Figs. 4a-d

This species is closely related to *Gonomyia* (*Lipophleps*) *hawaiiensis* Alexander and can be satisfactorily differentiated only by the male genital characters. The most striking difference is the bilobed development of the basistyli. A moderately strong secondary lobe is developed on the venter of each basistyle (figs. 4b and 4d). This lobe is absent in *hawaiiensis* (fig. 3).

Male. *Head:* The front is yellow, the occiput is yellow-brown covered with gray pollen. The mouthparts are brown, the labellum is tinged with yellow. The antennae are predominantly brown, faintly tinged with yellow. The first flagellar segment is yellow-brown to yellow. The flagellum is 14-segmented, the apical 8 to 10 segments are considerably smaller than are the basal segments. The antennae are rather strongly tapered. *Thorax:* The mesonotum is brown to blackish, except for the extreme ventral margins, the humeri and postalar areas, which are bright yellow. The pleura each have a broad yellow band extending from the front coxa through the hypopleuron. The sternum is yellow as is the scutellum, the wing bases, and the knobs of the halteres. The metanotum is yellowish brown. *Legs:* Predominantly brown with yellow coxae and brownish yellow trochanters. *Wings:* Hyaline with no infuscations. The venation is typical of members of this subgenus. The subcostal vein ends slightly before the middle of the wing and before the branching of the radial vein. Vein R_{1+2} extends to about the apical two-thirds to three-fourths of the wing and ends approximately opposite the m crossvein. The fifth section of the costa (that section between the ends of veins R_2 and R_{4+5}) is about one and one-half times longer than the fourth costal section. Vein R_{4+5} bends down rather sharply at its apical portion so that the apical cell (cell R_5) is rather strongly narrowed (fig. 4a). The m-cu crossvein is situated distinctly before the base of cell 1st M_2. This cell is about one-half as long as vein M_4. *Abdomen:* Nearly two times longer than the combined lengths of the head and thorax; it is chiefly dark brown, faintly tinged with yellow. The lateral margins are rather distinctly brownish yellow and the seventh segment is predominantly yellow, especially on the venter. *Genitalia:* Chiefly dark brown in color; the aedeagus and its accessory

EXPLANATION OF FIGURES ON OPPOSITE PAGE

1. **Limonia (Dicranomyia) iniquispina** n. sp. **a.** wing; **b.** male genitalia, ventral view; **c.** male genitalia, dorsal.
2. **Limonia (Dicranomyia) grimshawi** (Alexander). Right side of male genitalia, dorsal view.
3. **Gonomyia (Lipophleps) hawaiiensis** Alexander. Right side of male genitalia, ventral.
4. **Gonomyia (Lipophleps) molokaiensis** n. sp. **a.** wing; **b.** male genitalia, lateral; **c.** male genitalia, dorsal; **d.** male genitalia, ventral.

structures are yellow. The dististyli are bilobed (or partly trilobed), this is best seen in ventral or lateral views (figs. 4b and 4d). From a lateral view (fig. 4b) a small median lobe is developed between the dorsal and ventral lobes. The ventral lobe of each basistyle extends about half-way to the apex of the dorsal lobe. The dorsal lobe is shorter than the basal portion of the basistyle (fig. 4c). The dististyli are two pointed; the inner point or lobe is longer than the outer and bears some long dorsal hairs (fig. 4d). The lateral margins of the anal area are heavily sclerotized and appear to be densely covered with short, black hair, or numerous teeth or serrations (fig. 4c). The aedeagus is long and slender and the apical portion is elbowed and bent backwards.

Length: body, 3.0 mm.; wings, 4.0 mm.

Female. Fitting the description of the male except for genital characters.

Holotype male, allotype female, and 8 paratypes: 7 males and 1 female, Puu Kolekole, Molokai, (21° 6′ N., 156° 54′ W.), 4,000 ft. elev., July, 1952 (D. E. Hardy and M. Tamashiro). The specimens were taken by sweeping vegetation in a marsh on top of the Molokai mountains.

The holotype and allotype are being deposited in the United States National Museum. The paratypes are in the following collections: B. P. Bishop Museum, Hawaiian Sugar Planters' Association, C. P. Alexander and the University of Hawaii.

Studies in Hawaiian Dorilaidae (Diptera)[1]
Part I

By D. ELMO HARDY

ENTOMOLOGIST, HAWAII AGRICULTURAL EXPERIMENT STATION

The Dorilaidae have been very poorly known in Hawaii. The group was investigated in a preliminary way by Perkins[2] in connection with the work on the parasites of leafhoppers, but these flies have been neglected completely since the "FAUNA HAWAIIENSIS."

The family appears to be rather well developed in the Territory but to date only twelve species have been described. It is quite obvious that this figure represents a small portion of the species which actually exist here. I have been preparing a monograph of the Hawaiian species for some time and a considerable number of new species are now on hand. The keys and much of the other monographic information are now to be incorporated in one of the volumes of the Diptera section of "INSECTS OF HAWAII".

Dorilas (Dorilas) alienus new species (Figs. 1a-d)

This species is related to *D. swezeyi* (Perkins) and to *perkinsiellae* n. sp. It differs from the former by having the third antennal segment brownish, instead of bright yellow; by having the apical one-half to three-fourths of the fifth tergum of the male polished, instead of the entire abdomen being pollinose; by having a narrow membranous area just to the right of the apex of the male genitalia and the claspers terminating in two points, instead of having a broad membranous area extending over the entire right side of the genitalia and the claspers curved outwardly at their apices; also by having the female ovipositor extending to about the base of the abdomen, instead of being very short and reaching scarcely past the base of the fifth abdominal segment. It differs from *perkinsiellae* as discussed under that species and as shown in figs. 1c and 5c.

Male: *Head:* The junction of the compound eyes is about equal in length to the frontal triangle. The latter is gray to blackish pubescent, faintly shining down the middle. The face is white pubescent. The upper portion of the occiput is brownish gray, the remainder of the occiput is cinereous. The basal segments of the antennae are dark brown to black and the bristles on the underside of the second segment extend about three-fourths of the distance to the apex of the third segment. The third segment is brown, faintly tinged with yellow and is moderately acuminate below (fig. 1a). *Thorax:* Brown pollinose on the dorsum, gray on the sides. The mesonotum is subshining black and the pleura are black, tinged with rufous in their ground color. The humeri are black, faintly yellowed on their hind margins. The stems of the halteres are rufous, the knobs are brown to black. The scutellum has eight strong bristles on its hind margin. The dorsocentral bristles are erect and are moderately well developed.

[1] Published with the approval of the Director of the Hawaii Agricultural Experiment Station as Technical Paper No. 274.

[2] 1905, Report of the work of the Experiment Station of the Hawaiian Sugar Planters' Association, Bull. 1(4):152-155. 1913, FAUNA HAWAIIENSIS 2:697-699 and 3:17-19. Introduction, pp. clxxxiii-clxxxiv.

Legs: The coxae are dark brown to black, the legs are otherwise rufous, except for a tinge of brown on the apical subsegments of the tarsi. Flexor bristles are well developed on all femora and the hind tibiae have no strong bristles on the outside surface. *Wings:* Largely brownish fumose, subhyaline at the base. The stigma is dark brown and fills all of the third costal section. The third section is almost as long as the fourth and the two sections combined are about one and one-third times longer than the fifth. The r-m crossvein is situated at the basal third of the discal cell and the last section of the fourth vein is gently curved. *Abdomen:* Chiefly opaque brown with no gray fasciae except on the first tergum. The apical half to three-fourths of the fifth tergum is polished black. The abdomen is rather thickly covered with suberect, black setae. The first tergum has a row of about eight strong, black bristles on each side; the abdomen is otherwise covered with moderately dense, short, black hairs. *Genitalia:* From a dorsal view the visible genitalia are approximately half as long as the fifth abdominal segment. They are rounded, somewhat compressed to the right and with a small membranous area present at the right side of the apex. The seventh segment is plainly visible from a dorsal view (fig. 1b). The ninth segment is dark brown in color and the claspers are rufous, tinged with brown. The membranous area completely bisects the eighth segment on the venter and extends to the base of the ninth. The ninth segment[3] has a V-shaped cleft on its hind margin, extending nearly half the length of the segment. The claspers are symmetrical in shape and are bilobed at apices (fig. 1c).

Length: body, 4.0-4.5 mm.; wings, 5.0-5.8 mm.

Female. *Head:* The front is slightly expanded above the median portion. The upper third to two-fifths of the front is polished black. *Wings:* Slightly more hyaline than in the males. *Abdomen:* Subopaque black, gray pollinose on the first tergum and brownish gray on the remainder of the terga. The sixth segment is about equal in length to the fifth and is not excised on its hind margin. The sides of the abdomen are nearly straight. *Ovipositor:* Well developed and conspicuous, extending as far as the base of the abdomen; the apex of the piercer usually fitting between the hind coxae. The base is black and the piercer is rufous. The piercer is slightly longer than the base (fig. 1d).

Length: body, 3.3-3.6 mm.; wings, 4.5-5.0 mm.

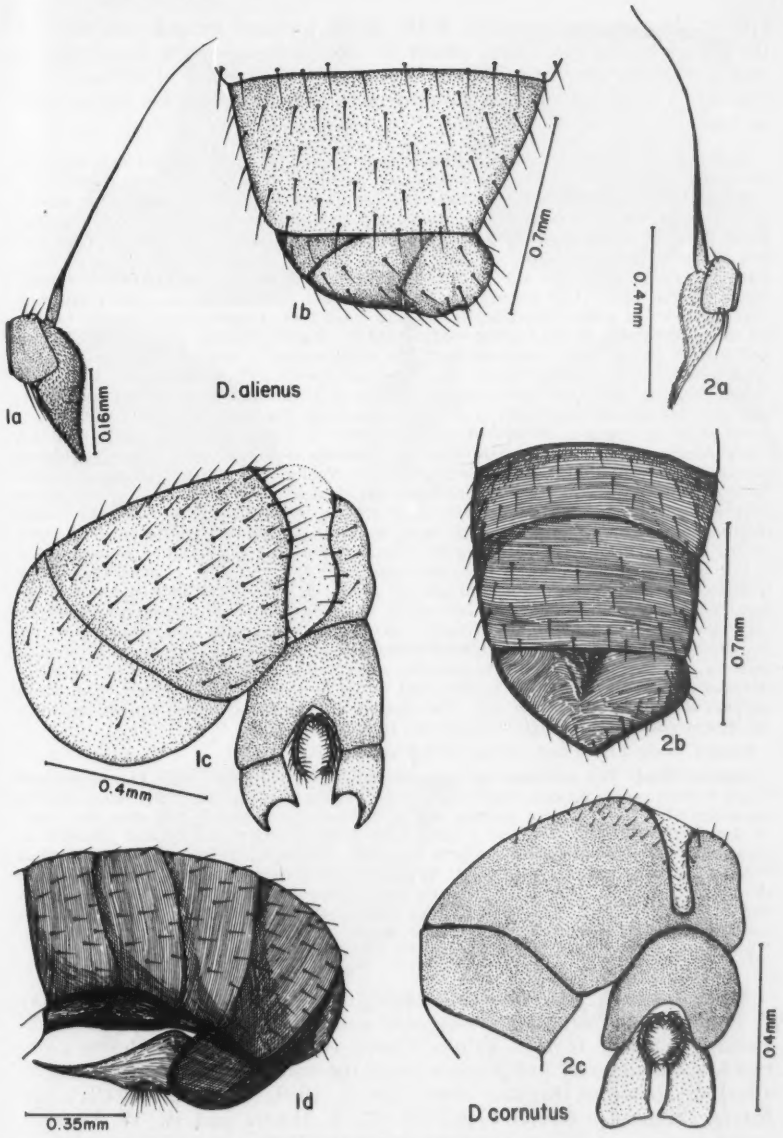
Holotype male and allotype female, Iao Valley, Maui, (20° 53′ N., 156° 33′ W.) elevation 1,500 feet, June, 1952 (D. E. Hardy). Seven paratypes, four males and three females from the following localities: Makamakaole Valley, Maui, June, 1952 (M. Tamashiro); ridge south of Iao Valley, Maui, September 14, 1919 (F. X. Williams); Kahuaawi Gulch, Molokai, July, 1952, over tree fern (*Cibotium chamissoi* Kaulf.) (D. E. Hardy and M. Tamashiro) and Manawainui Valley, Molokai, July, 1952, over *Nephrolepis biserrata* (Sw.).

Type and allotype in the United States National Museum. The paratypes are in the following collections: Hawaiian Sugar Planters' Association collection; University of Hawaii and the B. P. Bishop Museum.

Dorilas (Dorilas) cornutus new species (Figs. 2a-d)

This species is related to *D. hawaiiensis* (Perkins) but the posterior portion of the abdomen is polished black, not entirely pollinose as in that species. The genitalia of both sexes are very different in the two species. In *D. cornutus* the claspers are about two times longer than wide, are slightly expanded at apices; the hind margins of the ninth segment extend only to the bases of the claspers and to about the apical three-fourths of the cerci; the membranous area is also comparatively narrow on the venter, the width is less than the width of a clasper (fig. 2c). In *hawaiiensis* the claspers are about as wide as long and are bilobed at

[3] The details of the ventral aspects of the genitalia are described and figured from paratypes.



1. **Dorilus alienus** n. sp. **a.** antenna; **b.** male genitalia, dorsal; **c.** male genitalia, ventral; **d.** female abdomen, lateral.
2. **Dorilus cornutus** n. sp. **a.** antenna; **b.** male genitalia, dorsal; **c.** male genitalia, ventral.

apices; the posterior margins of the ninth segment extend well beyond the apices of the cerci and almost to tips of claspers, the membranous area is broader than the claspers. The female ovipositor of *cornutus* has a pair of strong tubercles on the underside (fig. 2d), these are not present in *hawaiiensis*.

Male. *Head:* The antennae are yellow except for the brownish colored first segment; the third segment is moderately acuminate (fig. 2a). *Thorax:* The mesonotum and scutellum are predominately brownish. The pleura are brown in ground color, dusted with gray pollen. The humeri are brown and the halteres are chiefly yellow with a slight brownish tinge on the knobs. The dorsocentral hairs are not strongly developed and the scutellum has a row of strong black bristles along the hind margin. *Legs:* Entirely yellow except for the brownish colored coxae and for the brownish subsegments of the tarsi. The femora are rather slender and the flexor spines are well developed on all pairs. The hind tibiae each have two or more strong brown bristles on the outside edge of the swollen surface. *Wings:* Slightly fumose, the stigma is brown and fills all of the third costal section. The third section is approximately one-half to three-fourths as long as the fourth. The third and fourth sections combined are slightly longer than the fifth. The r-m crossvein is situated at the basal one-third of cell 1st M_2 and the last section of vein M_{1+2} is slightly curved. The last section of vein M_{3+4} is about equal in length to the m crossvein. *Abdomen:* The sides are very slightly rounded; the abdomen is broadest at the junction of segments three and four. The first tergum is entirely gray pollinose; the second tergum is chiefly brown, gray on the sides; the third is brownish on the basal three-fourths polished to subshining black on the apical portion. In some specimens the entire third tergum is dusted with brown. The fourth tergum is dusted with brown on the basal one-third to one-half and is polished black on the apical portion. The fifth tergum is entirely polished black. The first tergum has a row of long brown colored hairs on each side; the abdomen is otherwise rather sparsely haired. *Genitalia:* The genitalia are almost as long as the fifth abdominal segment as seen from a dorsal view. The eighth segment is somewhat pointed at the apex and has a very large membranous area covering the entire right side of the apex (fig. 2b) from a ventral view the membranous portion almost completely bisects the eighth segment and extends nearly to its posterior margin; the extended portion of the membranous area is comparatively narrow and is not as broad as one clasper. The ninth segment is about as broad as long. The claspers are short and broad, square tipped at the apices and approximately symmetrical in shape (fig. 2c).

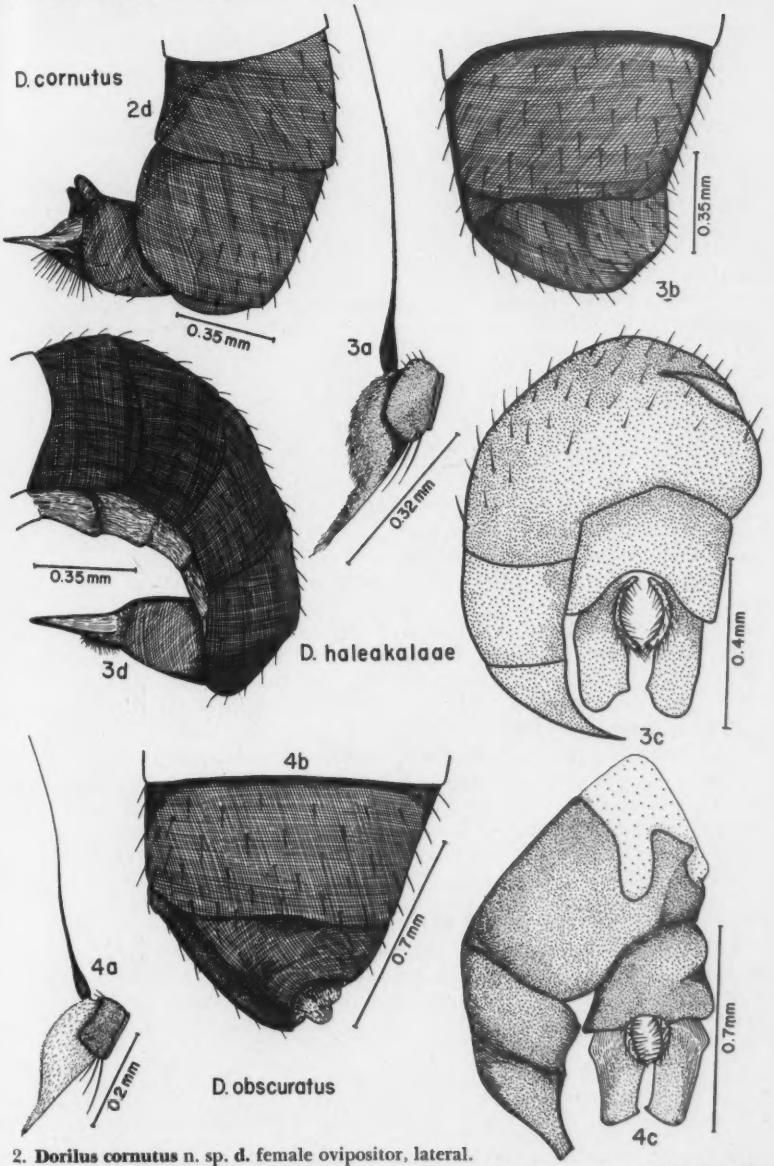
Length: body, 3.6-4.0 mm.; wings, 5.3-5.6 mm.

Female. *Head:* The antennae are more acuminate than in the male. The upper half of the front is polished black; the lower portion is silvery pubescent. The front is slightly expanded above the median portion and at the narrowest part is less than the width of the face. *Abdomen:* Entirely dusted with grayish brown pollen and broadest at about segment five. The sixth segment is poorly developed; it is scarcely one-third as long as the fifth segment. *Ovipositor:* The piercer is very short and scarcely extends to the base of the fifth segment. The piercer varies in color from reddish black to yellow and is slightly shorter than its base. The base of the ovipositor is entirely black and has a pair of strong horn-like tubercles developed on the underside (fig. 2d).

Length: body, 4.0 mm.; wings, 5.0 mm.

Holotype male, Mt. Tantalus, Oahu, (21° 20′ N., 157° 49′ W.) May 7, 1949 and August, 1952, flying over sword fern (*Nephrolepis*) (D. E. Hardy); allotype female, Palolo, Oahu, (O. H. Swezey). Eleven paratypes, six males and five females from the following localities: same as allotype; southeast Koolau Mts., May 8, 1919, (J. C. Bridwell); Mt. Kaala, Oahu, April-July, 1946-1952 (D. E. Hardy and W. W. Wirth); and Konahuanui, Oahu, October-November 1919.

The type, allotype and a series of paratypes are being deposited in the United States National Museum. The remainder of the paratypes are in



2. **Dorilus cornutus** n. sp. **d.** female ovipositor, lateral.
3. **Dorilus haleakalaae** n. sp. **a.** antenna; **b.** male genitalia, dorsal; **c.** male genitalia, ventral; **d.** female abdomen, lateral.
4. **Dorilus obscuratus** n. sp. **a.** antenna; **b.** male genitalia, dorsal; **c.** male genitalia, ventral.

the following collections: B. P. Bishop Museum, Hawaiian Sugar Planters' Association and the University of Hawaii.

Dorilas juvator melanopodis new subspecies

The specimens of *D. juvator* which have been collected on Maui are much more melanistic than the typical form and evidently represent a distinct subspecies. This subspecies is distinguished by its predominantly black coloration. The tibiae are nearly all black; the tarsal subsegments are blackened and the femora are very narrowly yellowed at their apices and bases. The trochanters are also brown to blackish, and the knobs of the halteres and the claspers are dark brown to black. In typical *juvator* the tibiae and the basal subsegments of the tarsi are yellow; the trochanters are yellow to rufous and the claspers and halteres are rufous. The bases and apices of the femora are conspicuously yellow, more broadly so in the females. The predominantly black legs fit this near *D. vulcanus* (Perkins), it is, however, readily distinguished by the genital characters and by the lack of a tibial spur on the hind legs of the males.

Both the males and the females fit the description of typical *juvator* except for the characters given above. As in *juvator juvator* the third antennal segment is more acuminate in the females and is paler in color than in the males.

Length: body, 3.5 - 4 mm.; wings, 4 - 5 mm.

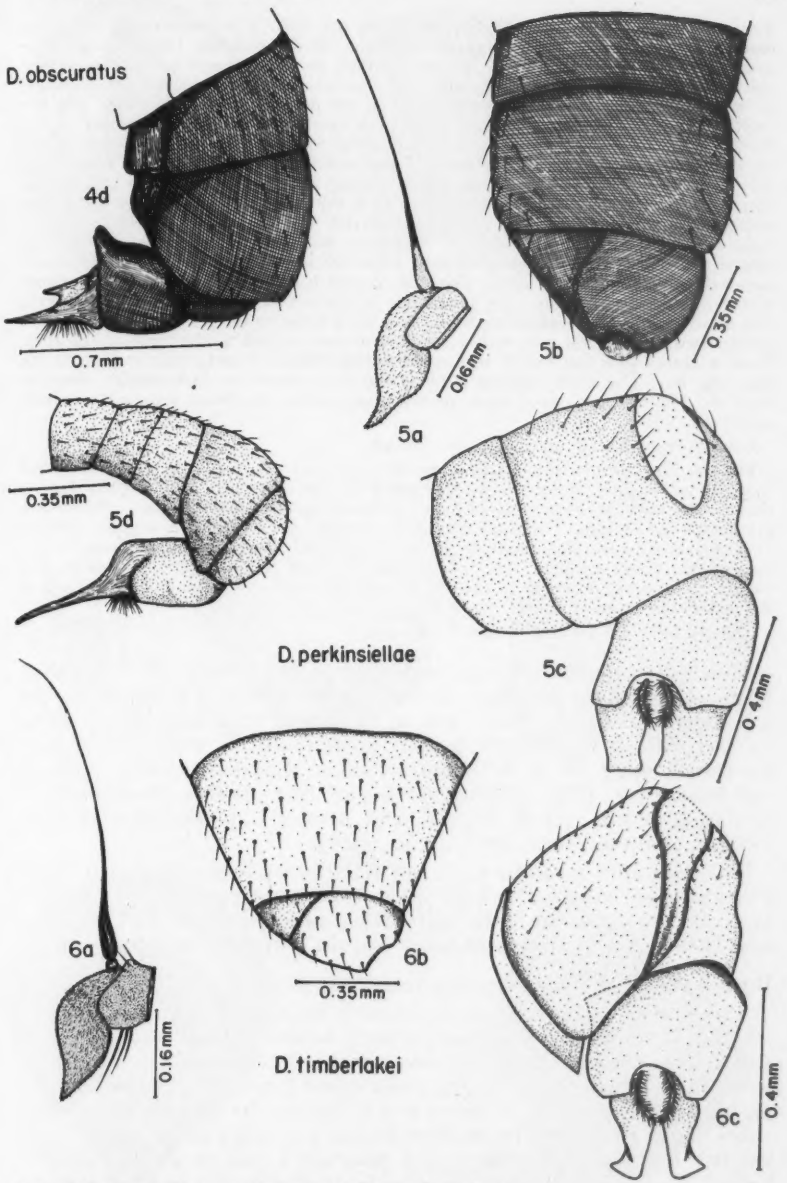
Holotype male and allotype female, Makamakaole Valley, Maui (20° 58′ N., 156° 32′ W.) June, 1952. (D. E. Hardy). Eighty-four paratypes; sexes about equally represented from the following localities: same as type, (D. E. Hardy and M. Tamashiro) and Iao Valley, 1,500 ft. elevation, June, 1952 (D. E. Hardy and M. Tamashiro). All of the above specimens were taken in false staghorn fern, "uluhe," (*Dicranopteris linearis* (Burm.)). These were taken in association with large numbers of specimens of a native leafhopper of the genus *Nesophrosyne*.

The holotype, allotype, and a series of paratypes are being deposited in the United States National Museum. Paratypes are also being deposited in the following institutions: B. P. Bishop Museum, Hawaiian Sugar Planters' Association, British Museum (Natural History) and University of Hawaii.

Dorilas (Dorilas) haleakalaae new species (Figs. 3a-d)

This species is related to *D. holomelas* (Perkins) and is differentiated by having the thorax and abdomen entirely pollinose and by the more acuminate third antennal segment and longer third costal section of the wing as well as by genital characters as described and figured below.

Male. The junction of the compound eyes is about equal in length to the frontal triangle. The front is dark gray to blackish pubescent and the face is cinereous; the face is slightly broader than the front. The upper third of the occiput is brownish pollinose, the lower portion is gray. The antennae are dark brown to blackish. The third antennal segment is drawn out into a long slender apex; this rostrate portion is about equal in length to the remainder of the third antennal segment (fig. 3a). *Thorax:* Brown pollinose on the dorsum, gray on the sides. The humeri are dark brown to black, faintly yellowish on the hind margin. The halteres are rufous with brown to black knobs. The hind margin of the scutellum possesses a row of moderately long bristles,



4. **Dorilus obscuratus** n. sp. **d.** female abdomen, lateral.
5. **Dorilus perkinsiellae** n. sp. **a.** antenna; **b.** male genitalia, dorsal; **c.** male genitalia, ventral; **d.** female abdomen, lateral.
6. **Dorilus timberlakei** n. sp. **a.** antenna; **b.** male genitalia, dorsal; **c.** male genitalia, ventral.

there are also a few scattered, short hairs on the disk. The dorsocentral hairs are moderately well developed but are not as strong as the scutellar bristles. *Legs:* The coxae are black and the femora are dark brown to black except for narrow yellow apices and bases. The tibiae are entirely yellow to rufous and the tarsi are yellow-brown to blackish. Flexor spines and extensor hairs are developed on all femora and the hind tibiae each have three or four long erect bristles on the outside surface of the swollen portion. *Wings:* Light brown fumose. The stigma is brown and fills all of the third costal section. The third section is equal or slightly longer than the fourth and the two sections combined are not quite as long as the fifth. The r-m crossvein is situated at the basal one-third to one-fourth of cell 1st M_2 (discal cell) and the last section of vein M_{1+2} (fourth vein) is slightly curved. The last section of vein M_{3+4} (fifth vein) is shorter than the m crossvein. *Abdomen:* Subopaque brown, gray on the first tergum and on the lateral margins. The sides are slightly rounded, the abdomen is broadest at about segment three. The first tergum has a dense row of about a dozen strong bristles on each side. The remainder of the abdomen is rather thickly covered with short suberect setae, these are longer and more dense on the fifth tergum. *Genitalia:* Compressed to the right and with a small membranous area to the right of the apex. From a dorsal view the eighth segment is about half to three-fourths as long as the fifth (fig. 3b). The ninth segment is black and the claspers are dark reddish brown to blackish. The claspers (based upon paratype specimens) are broad and blunt at their apices (fig. 3c).

Length: body, 3.8-4.2 mm.; wings, 5.5-6.0 mm.

Female. The front is chiefly gray, only the upper portion is shining black. The front is expanded slightly above the median portion. The wings are more lightly fumose than in the male. *Abdomen:* Chiefly gray pollinose lightly brownish down the median portion of the dorsum. The sides are nearly straight, the abdomen is slightly broadest at about segment five. The sixth segment is moderately developed, it is about half as long as the fifth. *Ovipositor:* The base is dark brownish red, the piercer is yellow. The base is about equal in length to the piercer and the latter extends to about the apex of the second abdominal segment (fig. 3d).

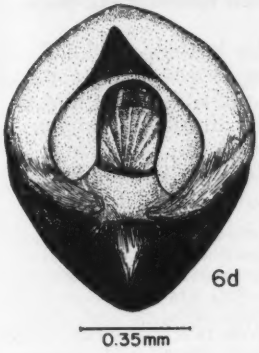
Length: body, 3.8-4.0 mm.; wings, 5.0-5.3 mm.

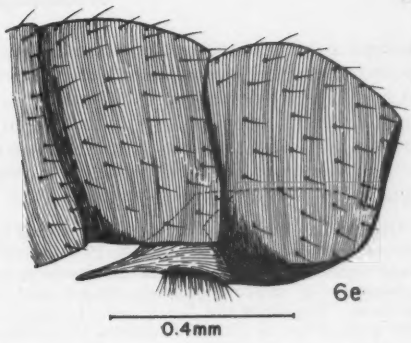
Holotype male and allotype female, Haleakala, Maui, 1919 (Timberlake). Twenty-two paratypes, sixteen males and six females, from the following localities on Maui: same as type; Kula Pipe Line, Maui, 4,500-5,000 ft., March 15, 1932 (O. Bryant); ridge south Iao Valley, Maui, September 14, 1919 (F. X. Williams); Paliku, Haleakala Crater, 6,500 ft. elevation, June, 1952, collected in "ohelo" berry bushes (*Vaccinium reticulatum* Smith) (D. E. Hardy) and Koolau Gap, Haleakala Crater, 7,000 ft. elevation, June, 1952 (D. E. Hardy).

The type, allotype and a series of paratypes are in the Hawaiian Sugar Planters' Association. The remainder of the paratypes are in the following collections: United States National Museum; British Museum (Natural History); B. P. Bishop Museum and the University of Hawaii.

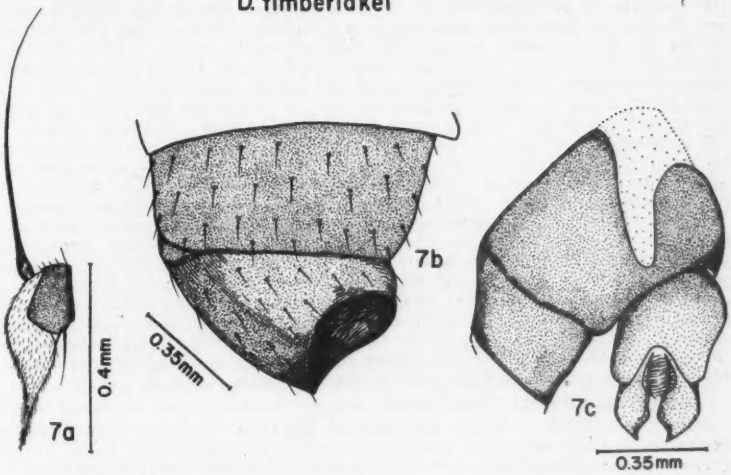
Dorilas (Dorilas) obscuratus new species (Figs. 4a-d)

This species is related to *D. cornutus* n. sp. and *D. hawaiiensis* (Perkins) but is readily distinguished by the genitalia of both sexes. It differs from *hawaiiensis* in having the apex of the fifth abdominal segment of the male polished; by having the ninth segment not extended beyond the apices of the claspers of the male; and by having the claspers about three times longer than wide, rather than having the width about equal to the length. The female ovipositor also possesses a pair of strong tubercles below. It is separated from *cornutus* by having brown to black median discolorations on the dorsal surfaces of the femora; by the more elongate,

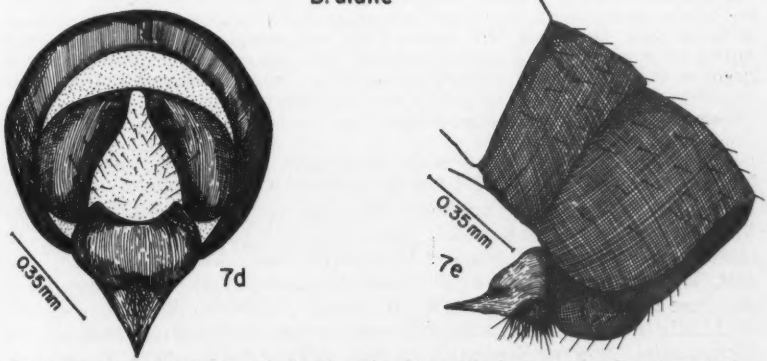




D. timberlakei



D. uluhe



6. **Dorilus timberlakei** n. sp. **d.** female ovipositor, end view; **e.** ovipositor, lateral view.
7. **Dorilus uluhe** n. sp. **a.** antenna; **b.** male genitalia, dorsal; **c.** male genitalia, ventral; **d.** female ovipositor, end view; **e.** female ovipositor, lateral.

straight side claspers; by the very shallow concavity of the posterior margin on the ninth segment, with the cerci extending well beyond the basis of claspers; by the short third costal section of the wing (one-third to one-fourth as long as the fourth section, rather than one-half to three-fourths as long); by the chiefly cinereous front of the female and by having the oviduct of the female ovipositor situated on a strong prominence (fig. 4d).

Male. *Head:* The lower portion of the front is silvery pubescent; the upper portion, just below the ocelli, is shining black. The first two antennal segments are black, the third segment is yellow. The third segment is long acuminate (fig. 4a). *Thorax:* The mesonotum is subshining black, dusted with brown pollen. The pleura are gray pollinose. The scutellum has a row of rather strong bristles along its hind margin. The humeri are black. The halteres are brown to black on their knobs and yellow on their stems. *Legs:* The coxae are black; the trochanters, femora, and tibiae are yellow except for a discoloration of brown to black on the median dorsal surface of each femur. The hind tibiae each have a row of three or more strong erect bristles on the outside of the swollen portion. The tarsi are chiefly brown to black. The flexor spines and extensor hairs are well developed on all femora. *Wings:* Distinctly brownish fumose. The stigma is dark brown in color and fills all of the third costal section. The third costal section is approximately one-fourth as long as the fourth section and the fourth section is almost equal in length to the fifth. Vein M_{1+2} is slightly sinuate. The r-m crossvein is situated at the basal one-third of cell 1st M_2. *Abdomen:* Chiefly brownish gray pollinose on the dorsum, cinereous on the first tergum and on the sides of the other terga; the fifth tergum is polished black on its apical one-third to one-fourth. The first segment has a row of 7 to 10 strong bristles on each side. *Genitalia:* Almost equal in length to the fifth abdominal segment and with a large membranous area on the right side of the apex (fig. 4b). The seventh tergum is plainly visible from a dorsal view. From a ventral view the membranous area is seen to cover the entire right side of the apex of the genitalia and almost completely bisects the eighth segment. The concavity on the posterior edge of the ninth segment is very shallow and the cerci extend well beyond the apical margins of the ninth segment. The claspers are rather elongate; they are slightly longer than the ninth segment and are approximately three times longer than wide. The claspers are approximately equal in size and shape, are blunt at apices with a very slight point on the inner edges (fig. 4c).

Length: body, 4.5 mm.; wings, 7.0 mm.

Female. The front is slightly expanded on the upper half and is gray pubescent except for the extreme upper portion, just below the ocelli. The thorax has more grayish on the dorsum than in the male and the abdomen is entirely pollinose. The discoloration on the dorsal surface of each femur is not as pronounced as in the male. The abdomen is slightly clavate, being broadest at the junction of segments four and five. The sixth segment is very poorly developed and is scarcely visible from a dorsal or lateral view. *Ovipositor:* The base is black and the piercer is yellow; the basal portion has a pair of strong tubercles beneath. The piercer is approximately equal in length to the base and the oviduct is situated on a strong prominence. The piercer extends to about the apex of the third abdominal segment (fig. 4d).

Length: body, 3.5-4.0 mm.; wings, 6.0 mm.

Holotype male, allotype female, and three paratypes, 2 males and 1 female; Keanakolu, Hawaii, 5,200 ft. (19° 55′ N., 155° 20′ W.), October, 1952, taken flying over *Cibotium chamissoi* Kaulf., in association with *Nesosydne ipomoeicola* Kirkaldy and with a *Nesophrosyne* species? (D. E. Hardy). Two paratype females from Bird Park, Kilauea, Hawaii, August, 1952, taken flying over *Pipturus hawaiiensis* (D. E. Hardy). One paratype female from Pauahi, Kona, Hawaii, 4,300 ft., August, 1952 (W. C. Mitchell) and one paratype female from Kealakekua, Hawaii, on *Clermontia*, 3,000 ft., November 8, 1919 (Timberlake).

The holotype and allotype are being deposited in the United States National Museum. The paratypes are in the following collections: B. P. Bishop Museum, Hawaiian Sugar Planters' Association, and the University of Hawaii.

Dorilas (Dorilas) perkinsiellae new species (Figs. 5a-d)

This species is related to *D. swezeyi* (Perkins) and to *alienus* n. sp. It differs from these by having the entire antennae, humeri and halteres yellow and the pleura chiefly yellow; by having the membranous area on the male genitalia apical instead of on the right side of the apex and not bisecting the eighth segment on the venter (fig. 5c), also by having the male claspers simple, without a pair of apical points.

Male. *Head:* The junction of the compound eyes is about equal in length to the frontal triangle. The frontal triangle and the face are densely gray pubescent. The antennae are entirely yellow except for a faintly brownish tinge on the first segment and on the base of the second segment. The third antennal segment is short acuminate (fig. 5a). The occiput is almost entirely gray pollinose, slightly brownish only at the extreme upper portion. *Thorax:* Mesonotum grayish brown pollinose, not distinctly grayed on the sides. The pleura as well as the metanotum and the scutellum, are gray pollinose. The humeri are yellow, very faintly tinged with brown. The halteres are yellow. The dorsocentral hairs are not conspicuously developed. The scutellum has a row of moderately long bristles along its hind margin and has a few scattered short hairs over the disk. *Legs:* Entirely yellow except for the brownish colored coxae. Flexor spines are well developed on all femora and the hind tibiae have no strong erect bristles on the outside surface. *Wings:* Faintly fumose, almost hyaline. The stigma is very pale brown and fills all of the third costal section. The third section is approximately one-half as long as the fourth, and the fourth is about equal in length to the fifth section. The r-m crossvein is situated near the basal third of cell 1st M_2, and the last section of vein M_{1+2} is strongly curved. *Abdomen:* Entirely grayish brown pollinose; more distinctly gray on the first segment and on the sides of the other segments. The sides of the abdomen are straight or nearly so. The first tergum has a row of strong, black bristles on each side. The abdomen is otherwise rather sparsely pilose. *Genitalia:* About equal in length to the fifth abdominal segment, as seen from a dorsal view; the eighth segment has a large apical membranous area (fig. 5b). The ninth segment and the claspers are rufous in color. From a ventral view (described and figured from paratype specimens) the membranous portion does not bisect the eighth segment. The ninth segment is about as wide as long and the claspers are rather short and broad; the outer clasper is the larger of the two. The claspers are rather truncate at apices and are slightly pointed at their inner apical margins (fig. 5c).

Length: Body, 4.0 mm.; wings, 5.0 mm.

Female. The upper one-third to one-fourth of the front is polished; the lower portion is cinereous. The front is slightly expanded at about the median portion. The thorax is almost entirely gray pollinose. The mesonotum has but a faint dusting of brown. Wings are completely hyaline except for the pale brown stigma. Pollinosity of the abdomen is similar to that of the male. The sixth abdominal segment is well developed and is almost equal in length to the fifth segment. The ovipositor is entirely yellow to rufous in color and extends to the base of the abdomen. The piercer is about equal in length to the base. The basal portion has a gentle tumescence on the underside (fig. 5d).

Length: body, 2.8-3.2 mm.; wings, 3.7-4.2 mm.

Holotype male and allotype female, Oahu Plantation, Field 40, (21° 26′ N., 158° 5′ W.), May 21, 1918, F. X. Williams. Eleven paratypes, nine males and two females: same as type; Waialua, Oahu, January 30, 1919; Honolulu, Oahu, March 1918-July 1919, reared from *Perkinsiella sac-*

charicida (O. H. Swezey and J. C. Bridwell), and Kuliouou, Oahu, July 12, 1918 (D. T. Fullaway).

The type, allotype and a series of paratypes are in the Hawaiian Sugar Planters' Association collection, the remainder of the paratypes are being deposited in the following collections: United States National Museum, B. P. Bishop Museum, and the University of Hawaii.

Dorilas (Dorilas) timberlakei[4] new species (Figs. 6a-e)

This species is closely related to *D. juvator* (Perkins) and has been confused with that species in the past. The two species obviously are found together in many localities (at least on Hawaii). In several instances specimens of *D. timberlakei,* in some of the collections, have been mounted on the same point with *juvator* specimens. In coloration and wing venation the two appear to be exactly alike, I have been able to separate them only by genital characters.

The male genitalia of *timberlakei* are not so well developed as are those of *juvator.* The genital portion of the abdomen is just slightly over half as long as the fifth abdominal segment in *timberlakei,* it is rather strongly compressed to the right and has the membranous area to the right of the apex and not clearly visible from a direct dorsal view (fig. 6b). In *juvator* the genitalia are not noticeably compressed to the right, and are about equal in length to the fifth segment. The membranous area is located in the middle of the apex of the eighth segment and extends conspicuously onto the dorsum of that segment. The claspers of *timberlakei* are truncate at their apices and are pointed at the outer apical edges (fig. 6c). In *juvator* the claspers are bilobed at apices and are very differently shaped. The female ovipositor of *juvator* is much more strongly developed and conspicuous. The base is not hidden and the piercer extends to about the apex of the second abdominal segment. In *timberlakei* the ovipositor is inconspicuous and is largely concealed by the sides of the fifth abdominal segment. The piercer is very short, extending to about the base of the fourth segment (fig 6e). The piercer, beyond the vulva, is scarcely longer than the vulva in *timberlakei* and in *juvator* it is at least three times longer. The most striking character in the females is the very poorly developed sixth abdominal segment of *timberlakei,* it is completely concealed (or nearly so) by the fifth segment (fig. 6d). In *juvator* the sixth segment is conspicuous and is equal in length to the fourth.

Male. *Head*: The compound eyes are joined on the front for a distance about equal to the length of the frontal triangle. The frontal triangle is gray-brown to blackish pubescent and has a narrow shining black line down the middle. The face and the lower two-thirds of the occiput are gray, the upper part of the occiput is brown to subshining black. The third antennal segment is short acuminate (fig. 6a) and dark brown to black in color. *Thorax:* Shining black or dark brown in ground color, brown pollinose on the dorsum and grayish on the sides. The humeri are black, tinged with yellow on their hind margins. The halteres are yellow, faintly tinged with brown. The scutellum has a row of moderately strong bristles around its hind margin. *Legs:* The coxae are black. The trochanters are brown to black tinged with yellow. The femora are black except for narrow yellow apices and

[4] Named in honor of P. H. Timberlake who exhibited much interest in these flies when he was working in Hawaii and who has contributed so much to our knowledge of parasitic Hymenoptera.

bases. Flexor spines and extensor hairs are moderately well developed on all femora. The tibiae are yellow, faintly tinged with brown towards the median portion. The tarsi are brownish, tinged with yellow. The hind tibiae have no strong erect bristles on the outside surface. *Wings:* Faintly brownish fumose, the stigma occupies all of the third costal section and is not much darker than the wing membrane. The third costal section is about three-fourths as long as the fourth and the two sections combined are about equal in length to the fifth section. The r-m crossvein is situated at about the basal one-third of cell 1st M_2 (discal) and the last section of vein M_{1+2} (4th vein) is very gently curved. The last section of vein M_{3+4} is shorter than the m crossvein. *Abdomen:* The first tergum is gray pollinose and has a row of strong black bristles on each side. The entire second and third, the basal three-fourths of the fourth, and the basal one-fourth of the fifth terga are opaque brown with no noticeable gray markings. The apex of the fourth tergum (in some specimens the middle of the apex of the 4th is opaque) and the apical three-fourths of the fifth are polished black. *Genitalia:* As described above and as shown in figures 6b and c. The membranous area is situated on the right side of the eighth segment and completely bisects the segment on the venter (fig. 6c).

Length: body, 4.2 mm.; wings, 5.0 mm.

Female. The front is slightly broader than the face and is expanded in the median portion. The upper half of the front is polished black, the lower half is cinereous. The third antennal segment is slightly more acuminate than in the male and the bases of the hind femora are more broadly yellowed. The wings are hyaline and the third costal section is but little over half as long as the fourth. *Abdomen:* Subopaque black, gray pollinose over the first two terga and on the sides of the remainder of the terga. Terga three to five dusted with brown dorsally. The sixth abdominal segment is very poorly developed and usually is not visible except in end view. In some specimens the sixth segment protrudes slightly beyond the fifth (as seen in lateral view) a distance equal to about one-seventh or one-eighth the length of the fifth. In end view the sixth segment is deeply concave on its hind margin and is slightly tumescent on the sides (fig. 6d); the narrow segment surrounds the base of the ovipositor. The ovipositor is as described above and as shown in fig. 6e.

Length: body, 3.7 mm.; wings, 4.3 mm.

Holotype male, allotype female and a series of paratypes from Keanakolu, Hawaii (19° 55′ N., 155° 20′ W.) elevation 5,200 ft., October, 1952, taken on *Cibotium chamissoi* Kaulf., in association with *Nesosydne ipomoeicola* Kirkaldy[5] and with a *Nesophrosyne* sp.? (D. E. Hardy). Approximately one hundred paratypes, both sexes, from the following localities: Mountain View, Hawaii, "Ja. 23 18"; Pahala, Hawaii, June 26, 1917 (O. H. Swezey); April, 1918 (F. X. Williams) and December 1, 1905 (no collector given); Kapapala, Hawaii, December 6, 1905; Kilauea, Hawaii, May, 1915 (A. Busck), November 4, 1919 (F. X. Williams), October, 1946 (C. J. Davis) and August, 1952, collected on *Pipturus hawaiiensis* (D. E. Hardy, W. C. Mitchell); Kulani, Hawaii, 5,200 ft., August 1952 (D. E. Hardy, W. C. Mitchell); 29 miles, Olaa, Hawaii, "flying over ferns," July, 1923 (W. M. Giffard); Kau, Hawaii, 2,000 ft., (no date or collector); Upper Hamakua ditch trail, Hawaii, July 31, 1921 (O. H. Swezey); Mt. Kaala, Oahu, March, 1925 (F. X. Williams), July 22, 1928, 2,000-3,000 ft., (E. H. Bryan) and June, 1952 (D. E. Hardy).

The holotype, allotype and a series of paratypes have been deposited in the United States National Museum. The remainder of the paratypes are in the following collections: Hawaiian Sugar Planters' Association,

[5] Perkins (1913: clxxxiii) said at least two species of *"Pipunculus"* are parasitic on this species. *D. timberlakei* is probably one of the species he observed.

B. P. Bishop Museum, University of Hawaii, and the British Museum (Natural History).

Dorilas (Dorilas) uluhe new species (Figs. 7a-e)

This species is related to *D. oahuensis* (Perkins). The males are distinguished by the large, conspicuous, membranous area which bisects the eighth abdominal segment (fig. 7c) and by having the genitalia (as seen from dorsal view) about equal in length to the fifth segment (fig 7b). In *oahuensis* the membranous area is poorly developed and is usually not visible in undissected specimens. The genitalia are smaller and about one-half as long as the fifth segment. The females are separated by the all pollinose abdomen of *uluhe* and by the very poorly developed, deeply cleft, sixth abdominal segment.

Male. *Head:* The junction of the compound eyes is slightly longer than the frontal triangle; the latter is densely gray pubescent. The face is silvery white pubescent and is slightly wider than the widest portion of the front. The upper portion of the occiput is subshining black, the remainder is gray. The first two antennal segments are black, the third segment is bright yellow. The third segment is long acuminate; the attenuated portion is approximately equal in length to the remainder of the segment (fig. 7a). *Thorax:* Entirely black, lightly subshining on the dorsum, thinly brownish pollinose; the pleura are faintly grayed. The dorsocentral hairs are distinct but are not unusually strong. The scutellum has a row of rather strong black bristles on the hind margin; the disc of the scutellum is almost devoid of hairs. The humeri are black, the halteres are yellow to rufous with brown to blackish knobs. *Legs:* The coxae and the apical subsegments of the tarsi are black. The trochanters, the tibiae and the basal subsegments of the tarsi are yellow. The femora are predominantly black with rather broad yellow bases and apices. Flexor spines and extensor hairs are well developed on all femora. The hind tibiae each have two very strong black bristles on the outside of the swollen portion. *Wings:* Distinctly pale brownish fumose. The stigma is brown and fills all of the third costal section. The third section is slightly shorter than the fourth. The two sections combined are a little longer than the fifth section. The r-m crossvein is situated near the basal third of cell 1st M_2. The last section of vein M_{1+2} is moderately curved. *Abdomen:* The first tergum is gray, the second and third are opaque grayish brown pollinose. The fourth segment is polished black on the apical half and opaque grayish brown on the basal portion. The fifth tergum is entirely polished black except for a very narrow grayish brown line along the basal margin. The abdomen is sparsely pilose; the pile is denser on the apical segments. *Genitalia:* Rather strongly compressed to the right and with a large sub-apical membranous area on the right side. The eighth segment is approximately equal in length to the fifth (fig. 7b). From a ventral view (described and figured from a paratype specimen) the membranous portion almost completely bisects the eighth segment and extends near the basal portion of the ninth (fig. 7c). The ninth segment is brown to blackish in color and is approximately as long as wide. The claspers are yellow to rufous in color and are sub-acutely pointed at their apices (fig. 7c). They are symmetrical in shape.

Length: body, 4.0-4.5 mm.; wings, 6.0-6.5 mm.

Female. *Head:* The front is conspicuously expanded on the upper portion. The upper one-third of the front is polished black; the remainder is gray. The lower portion of the front and the face are approximately equal in width. *Thorax:* As in the males except that the knobs of the halteres are faintly tinged with brownish. *Legs:* As in the males with the yellow bases and apices of the femora more extensive leaving a narrower black band around each femur. *Abdomen:* Opaque to sub-opaque; gray to grayish brown pollinose. The sixth abdominal segment is poorly developed and is scarcely visible from a direct dorsal view. From an end view the sixth segment is seen to be deeply concave on the posterior margin; the cleft almost completely bisects the sclerite (fig. 7d). *Ovipositor:* Very small and inconspicuous; usually completely hidden beneath the venter of the abdomen. The basal portion of the ovipositor

is black and the piercer is yellow to rufous. The piercer is approximately equal in length to the base and extends about to the basal portion of the fifth abdominal segment (fig. 7e). The piercer has a small tubercle beneath.

Length: body, 3.8-4.0 mm.; wings, 5.7-6.0 mm.

Holotype male, Makamakaole Valley, Maui, (20° 58′ N., 156° 32′ W.) June, 1952 (D. E. Hardy). Allotype female, same location and date as type (M. Tamashiro). Thirty-three paratypes, 17 males and 16 females, from the following localities: same as type, (D. E. Hardy and M. Tamashiro); Iao Valley, Maui, June, 1952 (D. E. Hardy and M. Tamashiro); Paliku, Haleakala crater, Maui, 6,500 ft., June, 1952 (D. E. Hardy and M. Tamashiro); Haelaau, Maui, 3,000 ft., December 18, 1928 (W. M. Walker) and ridge above Haelaau, Maui, 3,000-3,600 ft., December 19, 1928 (E. H. Bryan).

All of the above specimens (except the ones from Paliku and Haelaau) were taken in (or over) false staghorn fern, "uluhe" (*Dicranopteris linearis* (Burm.)). They were taken in association with a species of native leafhopper of the genus *Nesophrosyne*.

The holotype, allotype, and a series of paratypes are being deposited in the United States National Museum. The remainder of the paratypes are being deposited in the following collections: B. P. Bishop Museum, Hawaiian Sugar Planters' Association, British Museum (Natural History), and the University of Hawaii.

A Revision of the Genus Romblonella W. M. Wheeler (Hymenoptera: Formicidae)

By MARION R. SMITH

BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE
AGRICULTURAL RESEARCH ADMINISTRATION
UNITED STATES DEPARTMENT OF AGRICULTURE

In 1935 Wheeler established the monotypic genus *Romblonella,* basing it on the species, *grandinodis,* which he described from four workers collected by Señor L. Marato on Romblon Island, the Philippines. The genus was assigned by him to the tribe Meranoplini. *Romblonella* is distinguished from other genera of this tribe by the following characters: Antenna short, 12-segmented, with a distinct 3-segmented club; frontal carinae prolonged posteriorly to form the mesial borders of pronounced scrobes; thorax without promesonotal and mesoepinotal sutures; mesonotum not unusually large and neither dominating the epinotum nor bearing teeth or other appendages at its posterior border; epinotum bearing a pair of very distinct to well developed spines; petiole and postpetiole unusually voluminous; body length exceeding 2 mm.

Recently three additional species of *Romblonella* have been received for determination, each of which is new; one is from the island of Yap, another from the Fiji Islands, and the third from the island of Tinian. It appears that the ants of this group are confined to the Oriental and Australian regions. Unfortunately nothing is known of their biology.

Below are presented Wheeler's original characterization of the genus, his description and figures of the worker of *grandinodis,* my key for determining the workers of the various forms, and also my descriptions of the three new species. I have been fortunate in being able to study two imperfect cotype workers of *grandinodis* (the equivalent of one perfect cotype) given to the United States National Museum by the Museum of Comparative Zoology, Cambridge, Massachusetts.

Genus Romblonella W. M. Wheeler (Tribe Meranoplini)

Romblonella W. M. Wheeler, 1935, Proc. New England Zool. Club 15:5-9.

Worker: "Monomorphic, stout and thickset; integument hard, thick, very coarsely sculptured. Head subrectangular, with moderately large, convex eyes at the middle of the sides. Ocelli absent. Mandibles short, subtriangular, with strong, subequal teeth. Clypeus short and depressed on the sides, with broad, antero-posteriorly convex median portion, extending back between the frontal carinae, the anterior border without teeth. Frontal carinae widely separated, somewhat lobular and horizontal anteriorly, continued back to within a short distance of the posterior corners of the head as a pair of sharp, diverging ridges which form the mesial borders of distinct but shallow scrobes. Frontal area distinct but

shallow; frontal groove absent. Antenna short, 12-jointed; funiculi enlarged toward the tip, forming a very distinct 3-jointed club which is as long as the remainder of the funiculus, first funicular joint enlarged, nearly twice as long as broad, joints 2-8 short and transverse.

"Thorax stout, evenly convex above, without promesonotal and mesoepinotal sutures. Epinotum armed with a pair of long spines, which are placed rather low. Petiole and postpetiole very large, nodiform, the former narrow and subpedunculate anteriorly. Gaster broadly elliptical, formed very largely by the first segment. Sting small. Coxae small, legs stout, middle and hind tibiae spurless; tarsal claws simple."

Genotype: **Romblonella grandinodis** W. M. Wheeler (Fig. 1).

KEY FOR THE IDENTIFICATION OF THE WORKERS

1. Dorsal surface of first gastric segment densely and finely reticulate; epinotal spines approximately one-third of a millimeter in length..... 2
   Dorsal surface of first gastric segment largely smooth and shining except for small scattered groups of fine reticulae which are without any definite pattern of arrangement .....**vitiensis,** n. sp.
2. Petiole, from above, not subpyriform, scarcely longer than broad (one-fifth longer than broad); dorsal surface of head with irregular reticulae; mandibles, antennae, legs and epinotal spines not remarkably lighter in color than body and therefore not forming a distinct, bicolored appearance..... .....**grandinodis** W. M. Wheeler (fig. 1).
   Petiole, from above, subpyriform, very distinctly longer than broad; dorsal surface of head with prominent longitudinal rugulae which have a longitudinal trend; bicolored in appearance..... 3
3. Thorax, petiole and postpetiole light brown or yellowish brown; thoracic sculpture very fine, consisting largely of dense and very fine reticulae.....**townesi,** n. sp.
   Thorax, petiole and postpetiole black; thoracic sculpture much coarser than that of *townesi;* largely rugulose-reticulate, with the longitudinal rugulae predominating .....**yapensis,** n. sp.

Romblonella grandinodis W. M. Wheeler

Romblonella grandinodis W. M. Wheeler, 1935, Proc. New England Zool. Club 15:7-9, worker, fig. 2.; Chapman and Capco, 1952 (1951) Rep. of Philippines Inst. Sci. and Tech. Monogr. 1, p. 114.

Worker: "Length 4-4.5 mm.

"Head as broad as long, subquadrate, slightly broader behind than in front, with broadly and feebly concave posterior border, rounded posterior and anterior corners and rather straight sides. Eyes oval, rather convex, antero-inferiorly angular or bluntly pointed, situated about twice their length from the anterior corners of the clypeus. Mandibles stout, convex, with rounded external borders, the masticatory borders armed with six stout, but rather blunt, subequal teeth. Anterior clypeal border sinuate at the sides, in the middle with broad, straight and slightly projecting lobe. Frontal area rather large, triangular, rugulose. Antennal scapes about twice as long as the distance of their tips from the posterior corners of the head, curved at the base and not quite reaching the ends of the scrobes. First funicular joint nearly twice as long as broad, joints 2-8 nearly twice as broad as long, 9 and 10 subequal, distinctly longer than broad, together equaling the more enlarged terminal joint. Thorax about two and one-half times as long as broad, broadest through the pronotum, its dorsal outline in profile evenly convex; pronotum broad, slightly broader in front than behind, rising rather abruptly from the strong neck, with rectangular humeri and similar but blunter posterior angles at its lateral junctions with the mesonotum. Mesonotum distinctly concave at the sides, as long as the base of the epinotum which is shorter than the steep, concave declivity, the spines somewhat longer than their distance apart at the base and as long as the epinotum, directed backward and outward and distinctly curved inward. Being

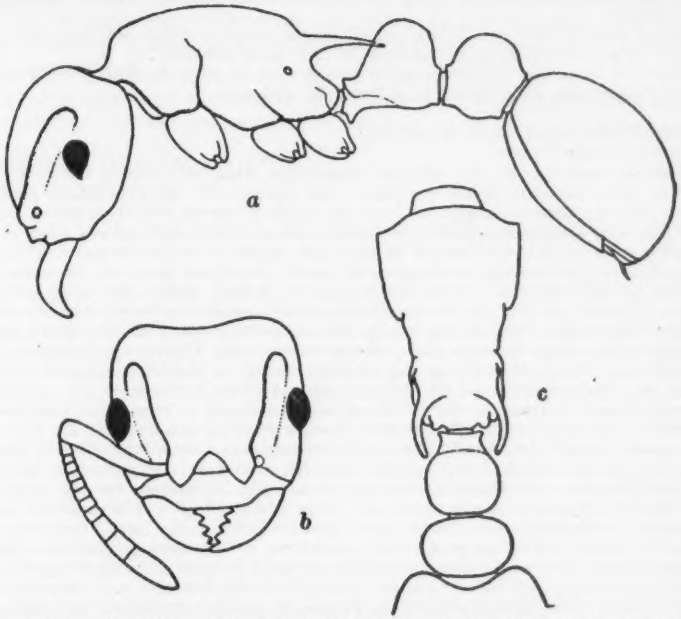


Figure 1. **Romblonella grandinodis** Wheeler. Worker: **a.** lateral aspect; **b.** head, dorsal aspect; **c.** thorax and pedicel, dorsal aspect (after Wheeler).

somewhat flattened dorso-ventrally, they appear more tapering and more acute in profile than when seen from above. Metasternal lobes distinct. Petiole nearly two-thirds as broad as the epinotum, about one-third longer than broad, broader behind than in front, where it is subrectangular, with the sides rounded behind; in profile it is nearly as high as long, with an acute antero-ventral tooth and the node, which is as high as the epinotum, strongly rounded—cuboidal, from above more hemispherical. Postpetiole about one-third broader than the petiole, nearly twice as broad as long, elliptical and strongly convex but lower than the petiolar node. Gaster about as large as the head, broadly and regularly elliptical, anterior border of first segment concave. Femora incrassated in the middle, tibiae stout and clavate.

"Sub-opaque; mandibles, antennae, coxae and legs distinctly shining. Mandibles coarsely longitudinally striate and sparsely punctate; remainder of body very finely and sharply reticulate, with the minute spaces between the reticulations shining under a high magnification and with the following superimposed rugosity: Head reticulate-rugose, the main rugae between the frontal carinae and on the broad median portion of the clypeus regular and longitudinal; scrobes reticulate, crossed by a few delicate rugules and bounded laterally by a longitudinal ruga; occiput, cheeks and sides of head more coarsely reticulate-rugose. Neck coarsely reticulate, thoracic dorsum reticulate-rugose, very coarsely on the pronotum, less sharply and less regularly on the mesonotum and base of epinotum; meso- and metapleurae, especially below, longitudinally rugose; declivity of epinotum sharply reticulate; nodes of petiole and postpetiole even more coarsely reticulate-rugose than the pronotum; gaster sharply but minutely reticulate throughout; scapes and legs with similar but less pronounced sculpture.

"Pilosity glistening white, moderately abundant, short, coarse, obtuse, erect, even and uniformly distributed over the body and appendages, somewhat longer on the abdomen than on the head and thorax, more oblique on the legs, on the antennae

somewhat finer, sub-erect on the scapes, sub-appressed on the funiculi. Pubescence undeveloped.

"Brown-black or very dark brown; mandibles, antennae and legs, including the coxae, and tip of gaster slightly paler, castaneous; tarsi more reddish.

"Described from four specimens taken May 6, 1928 by Senor L. Marato on Romblon Island, Philippines, and received from Dr. J. W. Chapman."

Romblonella yapensis, new species

Worker: Length 3.9 mm.

Head subquadrate, only very slightly longer than wide, with weakly convex or subparallel sides, rounded posterior corners and straight, or non-emarginate posterior border. Eye moderately large, oval, convex, not angular or bluntly pointed anteroventrally, with approximately 16 ommatidia in its greatest length; placed closer to the posterior than the anterior border of the head. Mandible about normal in size, subtriangular, the masticatory border with six teeth, the apical three of which are very distinct. Clypeus extended posteriorly between the frontal carinae, the anterior border sinuate laterally, in the middle forming a broad, projecting lobe which is almost straight transversely. Frontal area poorly defined, subtriangular, largely hidden by the rugulose sculpturing. Antenna short, 12-segmented; scape lacking approximately one-fifth of a millimeter of attaining the posterior border of the head, lying in a scrobe about the length of the scape, the mesial border of which is formed by the posteriorly diverging frontal carina, exterior border of scrobe without a carina; funiculus bearing a distinct 3-segmented club, which is clearly longer than the remainder of the funiculus, the second through the seventh funicular segments broader than long. Thorax dorsally without promesonotal and mesoepinotal sutures, widest at the pronotum which is distinctly angular anterolaterally and posterolaterally. Epinotum bearing a pair of dorsoventrally flattened spines which are about one-third of a millimeter in length, divergent basally and then becoming subparallel toward the apex, their tips not noticeably acute. Thorax, in profile, very noticeably arched anteroposteriorly, with the epinotal spines not strongly directed dorsally. Epinotal declivity beneath the spines with a pair of distinct, longitudinal carinae. Legs with incrassated femora, middle and hind tibiae without spurs, tarsal claws simple. Petiole, in profile, voluminous, the node somewhat subquadrate, with nearly perpendicular posterior face, rounded dorsal border, and long, inclined, almost straight anterior face; from above, the petiole is distinctly longer than broad, subpyriform. Postpetiole also voluminous; from above, transversely elliptical, about two-thirds as long as broad, and convex dorsally. Gaster elliptical, without basal humeri, the first segment occupying most of the dorsal surface.

Mandibles longitudinally striate and also sparsely punctate. Clypeus with a distinct median and a number of lateral carinae which are longitudinal in trend. Dorsal surface of head, especially the space between the frontal carinae with prominent, longitudinal rugulae. Antennal scrobes finely reticulate for the most part. Cheeks and sides of head rather coarsely rugulose-reticulate. Dorsal surface of thorax rugulose-reticulate, with the rugulae not especially coarse and usually with a longitudinal trend and dominating the reticulae. Sides of prothorax with coarse, longitudinal rugulae. Dorsal surfaces of petiolar and postpetiolar nodes finely reticulate with superimposed longitudinal rugulae. Dorsal surface of gaster finely and densely reticulate.

Hair moderately abundant, rather uniformly distributed on the body, white, short, coarse, erect, obtuse and nearly of equal length except at the apex of the gaster. Hairs on legs and scapes apparently shorter and more oblique. Pubescence on body very sparse or lacking.

Black, with reddish brown mandibles, antennae, and legs, the two colors being in strong contrast to each other. Epinotal spines also largely reddish brown, especially in some lights.

Type locality — Yap Island, R. J. Goss collector.

Described from a holotype and five paratype workers. All workers except one bear the label, "Centr. Yap Id., Yap Group, Jul.-Au. 50, R. J. Goss," the remaining specimen, a paratype worker, has a label that reads, "Tomil Dist., Yap Group, Jul.-Au. 50, R. J. Goss." The holotype and a single paratype worker have been assigned U. S. N. M. No. 61632

and placed in the collection of the United States National Museum. Two paratype workers each have been deposited in the Museum of Comparative Zoology, Cambridge, Massachusetts, and the Bishop Museum, Honolulu, Hawaii.

Paratypes are very similar to the holotype except for variations in the coarseness of the major sculpturing.

Romblonella vitiensis, new species

Worker: Length 4.1 mm.

Head subquadrate, only very slightly longer than broad, with weakly convex or subparallel sides, rounded posterior corners and faintly emarginate posterior border. Eye moderately large, oval, convex, placed closer to the posterior than the anterior border of the head. Mandible about normal in size, subtriangular, with such badly worn teeth that it is impossible to discern the exact original number. Clypeus extended posteriorly between the frontal carinae, the anterior border sinuate laterally, in the middle forming a broad projecting lobe which is almost straight transversely, the lobe with an impression near the center of the anterior border. Frontal area small, subtriangular, impressed, not clearly defined. Antenna short, 12-segmented; scape lacking approximately one-fifth of a millimeter of attaining the posterior border of the head, lying in a scrobe about the length of the scape, the mesial border of which is formed by the posteriorly diverging frontal carina, the exterior border of the scrobe without a carina; funiculus bearing a distinct 3-segmented club, which is clearly longer than the remainder of the funiculus, the second through the seventh funicular segments broader than long. Thorax dorsally without promesonotal and mesoepinotal sutures, widest at the pronotum which is distinctly angular anterolaterally and posterolaterally. Epinotum bearing a pair of spines which are about one-fifth of a millimeter in length and are directed lateroposteriorly and also somewhat dorsally, the spines not subparallel toward the apex as in *yapensis.* Epinotal declivity with a pair of longitudinal carinae beneath the spines. Legs with incrassated femora and tibiae, the middle and hind tibiae without spurs, the tarsal claws simple. Petiole in profile voluminous, the node subrectangular, with rounded dorsal border, short, sloping posterior face and long, inclined, almost straight anterior face; from above, the petiole is scarcely longer than broad, and with a node which is about one-fourth broader than long and subhemispherical. Postpetiole, in profile, not as high or as voluminous as the petiole; from above, the postpetiolar node is transversly elliptical, approximately one and one-third times as broad as long, with rather straight anterior and posterior face and rounded sides. Gaster elliptical, without basal humeri, the first segment occupying most of the dorsal surface.

Mandibles longitudinally striate and also sparsely punctate. Clypeus laterally with a number of longitudinal carinae but lacking the median carina of *yapensis.* Surface of head between the frontal carinae coarsely rugulose-reticulate, the rugulae with a general longitudinal trend, the interspaces finely reticulate. Antennal scrobe largely reticulate but also with a few, transverse rugulae. Cheeks and sides of head rather coarsely reticulate with finely reticulate interspaces. Pronotum rather coarsely reticulate, the mesonotum and epinotum more finely so, the interspaces also finely reticulate. Propleuron and mesopleuron largely longitudinally rugulose with reticulate interspaces. Dorsal surface of petiolar and postpetiolar nodes rugulose-reticulate with finely reticulate interspaces, the sculpturing somewhat intermediate in character between that of the head and thorax. Dorsal surface of gaster largely smooth and shiny, with small groups of fine reticulae scattered here and there, which do not seem to form a definite pattern and are not readily observed upon superficial examination.

Hair of about the same character and abundance as with *yapensis.*

Body dark brown, with lighter mandibles, antennae and legs.

Type locality — Wakaya, Fiji Islands, E. H. Bryan.

Described from a holotype worker collected October 17, 1924. The holotype has been placed in the Bishop Museum, Honolulu, Hawaii.

Romblonella townesi, new species

Worker: Length 4 mm.

Head subquadrate, slightly longer than broad, with weakly convex or subparallel sides and almost straight posterior border. Eye moderately large, oval, convex, placed almost equidistant from the anterior and posterior border of the head. Mandible about normal in size, subtriangular, the masticatory border with six teeth. Clypeus extending posteriorly between the frontal carinae, the anterior border sinuate laterally, in the middle forming a broad, projecting lobe which is almost straight transversely. Frontal area poorly defined, subtriangular, somewhat obscured by the rugulose sculpturing. Antenna short, 12-segmented, scape lacking approximately one-fifth of a millimeter of attaining the posterior border of the head, lying in a scrobe about the length of the scape, the mesial border of which is formed by the posteriorly diverging frontal carina, exterior border of scrobe without a lateral carina; funiculus bearing a distinct 3-segmented club, which is clearly longer than the remainder of the funiculus; the second through the seventh funicular segments broader than long. Thorax dorsally without promesonotal and mesoepinotal sutures, widest at the pronotum which is angulate anterolaterally and posterolaterally. Epinotum bearing a pair of well developed spines which are approximately one-third of a millimeter in length, curved outwardly at the base and becoming more subparallel apically; in profile the spines are almost horizontal and the basal half of each spine is much wider than the apical half. Thorax, in profile, noticeably and rather evenly arched anteroposteriorly. Legs with incrassated femora, middle and hind tibiae without spurs, tarsal claws simple. Petiole, in profile, voluminous, the node somewhat subquadrate, with long, inclined, almost straight anterior face, rounded dorsal border and sloping posterior face; from above, the petiole is subpyriform, approximately three-fifths as broad as long. Postpetiole also voluminous; from above transversely elliptical, about two-thirds as long as broad, convex dorsally. Gaster elliptical, without basal humeri; the first segment occupying most of the dorsal surface.

Mandibles longitudinally striate, also sparsely punctate. Clypeus with several distinct, longitudinal carinae, the interspaces finely reticulate. Dorsal surface of head, especially the space between the frontal carinae largely longitudinally rugulose, the interspaces finely reticulate. Most of the antennal scrobe reticulate. Cheeks rugulose-reticulate. Dorsal surface of thorax weakly sculptured, the ground surface consisting of very fine and dense reticulae. Through much of the promesonotum there are also some weakly developed longitudinal rugulae which are not easily discernible because of the nature of the color of the thorax. Petiole and postpetiole very feebly sculptured, the sculpture also not easily discernible because of the color of the two. Dorsal surface of first gastric segment densely and finely reticulate, sub-opaque in some lights, more shining in others.

Pilosity in general, similar to that of the other species.

Thorax, petiole and postpetiole light brown or yellowish brown; head, gaster and appendages darker, almost blackish, especially the head and gaster, the two colors in decided contrast. Posterior corners of the head lighter than the remainder of the dorsal surface.

Type locality — Mt. Lasso, Tinian Island.

Described from a holotype and two paratype workers collected June 12, 1946, by H. K. Townes, which bear his collection number 646. The holotype and paratypes have been placed in the United States National Museum and assigned No. 61633. The species is named in honor of Dr. Townes. The paratypes differ from the holotype mainly in size, one is 3.8 mm. long, the other 4.4 mm.

Belonging to this same species but not designated as types are three workers collected on Tinian, June 8, 1946, by Townes and bearing collection number 488; also a single worker collected in Marpo Valley, Tinian Island, June 8, 1946, by R. G. Oakley, bearing the number 517. These have not been included in the description because they belong to different series from the types. All these specimens have been placed in the United States National Museum.

Insect Records from Johnston Island[1]

By L. M. CHILSON

Johnston Island is a small atoll, about 700 miles west-southwest of Honolulu, consisting of two tiny islets and a reef some 12 miles around. Its insect fauna is necessarily limited, and until the recent war, was but little known. The present list is believed to include all known insect records from Johnston to mid-summer of 1952. About half of the species were collected for the first time by Kenneth L. Maehler during visits in 1947 and 1952; unless otherwise noted, he made the captures listed here. Other records were made earlier, notably by members of the Bishop Museum's "Tanager" Expedition in 1923, and by Ashley C. Browne in 1942. The results of the "Tanager" Expedition were published in 1926 as a Bishop Museum Bulletin, and citations of "Bull. 31" refer to that report on the "Tanager" collections. References to "PROCEEDINGS" are to the Proceedings of the Hawaiian Entomological Society.

ORTHOPTERA

Blattidae

Blattella lituricollis (Walker); det. A. B. Gurney. June 1, 1952, on the ground.
Cutilia soror (Brunner) (Bull. 31:89).
Periplaneta americana (L.) (Bull. 31:89).
Pycnoscelus surinamensis (L.) (Bull. 31:89).

DERMAPTERA

Labiduridae

Anisolabis maritima (Géné) (Bull. 31:82).
Euborellia annulipes (Lucas); det. A. B. Gurney. December 9, 1947, under board. Also taken by the "Tanager" party (Bull. 31:82).

MALLOPHAGA

Menoponidae

Austromenopon sternophilum (Ferris); det. C. F. W. Muesebeck. June 1, 1952, on tern.

THYSANOPTERA

Aeolothripidae

Frankliniella sulfurea Schmutz. Taken on Johnston by Krauss in 1946 ("PROCEEDINGS," 13: 9).

HEMIPTERA

Lygaeidae

Nysius terrestris Usinger. Taken by Krauss in 1946 ("PROCEEDINGS," 13:9).
Geocoris punctipes (Say); det. R. I. Sailer. Collected by L. B. Loring, July 8, 1948, on *Vitex trifolia*.

[1] The author wishes to thank the Editor of these "PROCEEDINGS" for help in the preparation of this paper.

Reduviidae

Zelus renardii Kolenati; det. E. C. Zimmerman. December 9, 1947, on *Scaevola frutescens;* June 1, 1952, on *Pluchea indica.*

Nabidae

Nabis capsiformis Germar (Bull. 31:80; as *Reduviolus*).

Gerridae

Halobates sericeus Eschscholtz (Bull. 31:80).

HOMOPTERA

Aphididae

Aphis gossypii Glover; det. L. M. Russell. June 1, 1952, on *Pluchea indica.*

Aphis medicaginis Koch; det. L. M. Russell. December 9, 1947, on *Tribulus cistoides* and *Portulaca oleracea.* Collected earlier by "Tanager" Expedition and by Browne. (Bull. 31:81; "PROCEEDINGS," 11:271, 1943).

Margarodidae

Icerya purchasi Maskell; det. Harold Morrison. December 9, 1947, on *Pluchea indica;* June 1, 1952, on *Scaevola frutescens.*

Pseudococcidae

Pseudococcus (citri complex); det. Harold Morrison. December 9, 1947, on *Scaevola* sp.

Pseudococcus sp. perhaps **citri** (Risso); det. Harold Morrison. December 9, 1947, on "be-still" tree (*Thevetia*).

Ferrisiana virgata (Cockerell); det. H. Morrison. Collected by L. B. Loring, July 8, 1948.

Coccidae

Coccus sp.; det. H. Morrison. Collected by L. B. Loring, July 8, 1948, on *Hibiscus tiliaceus.*

Coccus hesperidum L.; det. Harold Morrison. December 9, 1947, on "be-still" tree and an undetermined plant.

Saissetia nigra (Nietner); det. Harold Morrison. June 1, 1952, on *Ricinus communis.*

Saissetia oleae (Bernard); det. Harold Morrison. June 1, 1952, on *Hibiscus* sp.

Diaspididae

Aspidiotus lataniae Signoret; det. Morrison. December 9, 1947, on *Crotalaria* and an undetermined "sage."

Chrysomphalus dictyospermi (Morgan); det. H. Morrison. Collected by L. B. Loring, July 8, 1948.

Pinnaspis sp. (insufficient material); det. Morrison. December 9, 1947, on *Thespesia populnea.*

Pinnaspis strachani (Cooley) (of Ferris and Rao); det. Morrison. December 9, 1947, on *Tribulus cistoides.*

NEUROPTERA

Hemerobiidae

Sympherobius sp., may be **barberi** Banks; det. A. B. Gurney. December 9, 1947, flying. Krauss took *S. barberi* on Johnston in 1946 ("PROCEEDINGS," 13:9).

LEPIDOPTERA

Tineidae

Tineola uterella Walsingham (Bull. 31:76).

Ereunetis incerta Swezey (Bull. 31:77).

Pterophoridae

Trichoptilus oxydactylus (Walker) (Bull. 31:75).

Phalaenidae

Achaea janata (L.); det. H. W. Capps. December 9, 1947, on *Ricinus communis.*

Laphygma exempta (Walker). Determined by O. H. Swezey from caterpillars collected by Browne ("PROCEEDINGS," 11:281).

Laphygma exigua (Hubner). This species was reported from Johnston as early as 1943 ("PROCEEDINGS," 12:10, 1944).

COLEOPTERA

Dermestidae

Dermestes ater Degeer. Collected by both the "Tanager" Expedition (under dead birds) and by Browne (Bull. 31:46; "PROCEEDINGS," 11:271). (As *D. cadaverinus* F.).

Histeridae

Carcinops quattuordecimstriata (Stephens) (Bull. 31:47).

Anobiidae

Lasioderma serricorne (F.) (Bull. 31:48).

Tenebrionidae

Alphitobius piceus (Olivier); det. R. E. Blackwelder. June 1, 1952, from dead bird. Previously recorded with a query by "Tanager" Expedition (Bull. 31:48).

Coccinellidae

Coelophora inaequalis (F.); det. E. A. Chapin. December 9, 1947, on *Scaevola frutescens.*

Scymnus loewii Mulsant; det. E. A. Chapin. December 9, 1947, on *Thespesia populnea.*

Scymnus notescens Blackburn ?; det. E. A. Chapin. June 1, 1952.

Curculionidae

Dryotribus mimeticus Horn (Bull. 31:55).

Macrancylus immigrans (Perkins) (Bull. 31:57).

HYMENOPTERA

Encyrtidae

Aenasius advena Compere; det. B. D. Burks. June 1, 1952, in flight. Collected on Johnston in 1946 by Krauss ("PROCEEDINGS," 13: 9).

Leptomastix dactylopii Howard; det B. D. Burks. June 1, 1952.

Formicidae

Solenopsis geminata rufa (Jerdon); det. M. R. Smith. December 9, 1947, associated with *Icerya purchasi* on *Pluchea indica;* June 1, 1952, on ground.

Monomorium pharaonis (L.) The late Dr. W. M. Wheeler believed that the Johnston Island forms of this ant should be separated as a new subspecies (Bull. 31:18).

Cardiocondyla sp.; det. M. R. Smith. December 9, 1947, on *Pluchea indica.*

Tetramorium guineense (F.); det. M. R. Smith. June 1, 1952, on the ground.

Paratrechina (Nylanderia) sp.; det. M. R. Smith. December 9, 1947, associated with *Icerya purchasi* on *Pluchea indica.*

Paratrechina longicornis (Latreille); det. M. R. Smith. June 1, 1952, on the ground.

Sphecidae

Chalybion bengalense (Dahlbom); det. K. L. Maehler. Taken by Maehler June 1, 1952.

Vespidae

Polistes fuscatus aurifer Saussure; det. K. V. Krombein. December 9, 1947, in flight.

Megachilidae

Megachile fullawayi Cockerell; det. K. V. Krombein. June 1, 1952, on *Pluchea indica.*

DIPTERA

Syrphidae

Simosyrphus (Xanthogramma) grandicornis (Macquart) (Bull. 31:68). Bryan notes that this species was seen but not captured. (A synonym of the following species).

Xanthogramma scutellaris (F.); det. W. W. Wirth. June 1, 1952, flying.

Syrphus sp.; det. C. T. Greene. December 9, 1947, with aphids.

Sarcophagidae

Goniophyto bryani Lopes. This is the species reported by the "Tanager" Expedition as a new genus and species (Bull. 31:68). It was described as *G. bryani* in 1938 (Bishop Mus. Occ. Papers, Vol. 14, No. 11:195).

Sarcophaga sp.; det. C. W. Sabrosky. June 1, 1952, flying.

Sarcophaga dux Thomson; det. Sabrosky. June 1, 1952, flying.

Sarcophaga barbata Thomson. Reported by Krauss in 1946 ("PROCEEDINGS," 13:9).

Calliphoridae

Phaenicia sp.; det. Sabrosky. June 1, 1952, flying.

Muscidae

Musca domestica L. Reported by Browne ("PROCEEDINGS," 11:271).

Musca domestica vicina Macquart (Bull. 31:68). Considered by some a subspecies of *domestica* ("PROCEEDINGS," 14:480, 1952).

Atherigona excisa (Thomson). Recorded with a query by Swezey from material collected by Browne ("PROCEEDINGS," 11:271).

Milichiidae

Desmometopa sp. Reported as *D. m-nigrum* Zetterstedt by Krauss in 1946 ("PROCEEDINGS," 13:9).

Agromyzidae

Agromyza pusilla Meigen (Bull. 31:70). Recorded in the "Tanager" report as ". . . abundant about Tribulus blossoms." Recent studies by Frick show the *pusilla* complex in the Pacific consists of numerous species, probably none of them *pusilla.*

Hippoboscidae

Olfersia spinifera (Leach); det. Alan Stone. June 1, 1952, from frigate birds. This fly was also collected by the "Tanager" Expedition (Bull. 31:71).

New Host and Insect Records from the Island of Hawaii

By C. J. DAVIS

ACACIA KOAIA

This native tree resembles *Acacia koa* and grows in the Kawaihae-uka region of the Kohala Mountains on the island of Hawaii. A few trees have been reported at Puuanahulu ridge, North Kona. It is becoming rare, and neither the tree nor its insect fauna has hitherto been recorded in entomological literature.

From dead branches and twigs collected between January and March, 1952, there issued numerous longicorn beetles which were identified by Dr. O. H. Swezey as *Neoclytarlus nodifer* (Sharp). This beetle was first recorded from *Acacia koa* in Kona, Hawaii by R. C. L. Perkins in 1896. In further collecting in 1952, an undescribed cerambycid species of *Plagithmysus* was beaten from the foliage of a young, healthy tree. Additional specimens of this new species were subsequently collected and reared.

Other insects found on *Acacia koaia* were the following:

	FOLIAGE	
Coleoptera	**Pantomorus godmani** (Crotch)	abundant
	Diachus auratus (F.)	few
	Cryptolaemus montrouzieri Mulsant	occasional
Hemiptera-Heteroptera	**Coleotichus blackburniae** White	common
	Orthotylus sp.	occasional
	Nysius nigriscutellatus Usinger	occasional
	Koanoa sp.	numerous
Hemiptera-Homoptera	**Siphanta acuta** (Walker)	few
	Nesosydne rubescens (Kirkaldy)	abundant
	Icerya purchasi Maskell	few
Lepidoptera	**Amorbia emigratella** Busck	few
	Lycaena blackburni (Tuely)	few
	SEED PODS	
Lepidoptera	**Argyroploce illepida** (Butler)	abundant
Hemiptera-Homoptera	**Planococcus (Pseudococcus) citri** (Risso)	few
	TWIGS AND BRANCHES	
Coleoptera	**Sinoxylon conigerum** Gerstaecker	few
	Xylopsocus castanoptera (Fairmaire)	few
	Epitragus diremptus Karsch	occasional
	Araecerus vieillardi (Montrouzier)	
Lepidoptera	**Orthomycena** sp.	occasional
	Enarmonia walsinghami (Butler)	
	Decadarchis minuscula (Walsingham)	
Hymenoptera	**Trichogramma minutum** Riley	few
	Pristomerus hawaiiensis Perkins	few
Thysanoptera	**Haplothrips rosai** Bianchi	abundant
Corrodentia	**Caecilius analis** Banks	
	Psocus distinguendus Perkins	
	Psocus konae Perkins	

DUBAUTIA MONTANA

This native plant is fairly abundant on the north side of the saddle road between Pohakuloa and Waikii, at 6,400 feet elevation. From dead twigs and branches collected in May and June, 1952, five *Neoclytarlus* sp. emerged. These beetles are close to *Neoclytarlus railliardiae* Perkins, a species collected from *Dubautia ciliolata* on the summit of Haleakala, Maui, June 17, 1927, by Dr. O. H. Swezey.

ACACIA DECURRENS

In July, 1952, branches and twigs of a dying wattle tree in Peacock's pasture, Kamuela, 3,000 feet elevation, were found heavily infested with a native beetle, *Neoclytarlus nodifer* (Sharp). This is the third hostplant record of this endemic cerambycid, and the first exotic hostplant record for any beetle of this genus in Hawaii. Maehler ("PROCEEDINGS," 13:203, 1948) bred the native *Plagithmysus newelli* Sharp from the introduced *Nicotiana glauca* on Maui.

Other beetles reared from wattle include *Neoclytarlus claviger* Sharp, one specimen; *Neoclytarlus* sp., one specimen; and *Cylindera flava* (F.), two specimens.

The wattle is closely related to *Acacia koa* and *A. koaia,* and, from all indications, seems well suited to several species of native longicorns. The help of Dr. O. H. Swezey and of Messrs. Zimmerman and Bianchi in identifying the insects named above, is gratefully acknowledged.

Two New Diaspidid Scales on Araucaria[1]

By MARIAN S. ADACHI and DAVID T. FULLAWAY

UNIVERSITY OF HAWAII, AGRICULTURAL EXPERIMENT STATION, AND BOARD OF AGRICULTURE AND FORESTRY, HONOLULU, HAWAII

The diaspidid coccids found on *Araucaria*, recorded last year in the PROCEEDINGS of the Hawaiian Entomological Society (14:346 and 348, 1952) apparently represent two undescribed species. Specimens of both species were sent to Dr. G. F. Ferris of Stanford University who confirmed that they are undescribed. In Dr. Ferris' opinion these species best fit into the genera *Pseudoparlatoria* (Diaspidini) and *Octaspidiotus* (Aspidiotini). The *Pseudoparlatoria* was collected in Hawaii nearly half a century ago, as evidenced by a slide mount of a diaspidid parasite, *Aphytis chrysomphali* (Mercet) which is in the Board of Agriculture and Forestry collection, and which bears a label "ex *Pseudoparlatoria giffardii* Kot. n. sp. on *Araucaria excelsa*, W. M. Giffard, 29-VI-07" in the handwriting of Jacob Kotinsky, an entomologist formerly with the Board of Agriculture and Forestry. *P. giffardii* was a manuscript name of Kotinsky's and was published as a *nomen nudum* in a list of scale insects and their natural enemies ("PROCEEDINGS," 4:246, 1920 and 8:113, 1932). The *Octaspidiotus* was first recorded in Hawaii in 1951. It is not as widespread or abundant as the *Pseudoparlatoria* and to date is known from only one species of *Araucaria*.

Both of these species are obviously immigrants to Hawaii but so far it has not been possible to determine where they are endemic. It appears that the *Pseudoparlatoria* probably came from the Neotropical region, and the *Octaspidiotus* surely must have been imported from somewhere in the southwest Pacific. The senior author has written to a number of entomologists throughout the Pacific area in an attempt to obtain scale insects from *Araucaria* for comparison with our material but, to date, has not received any specimens of diaspidids.

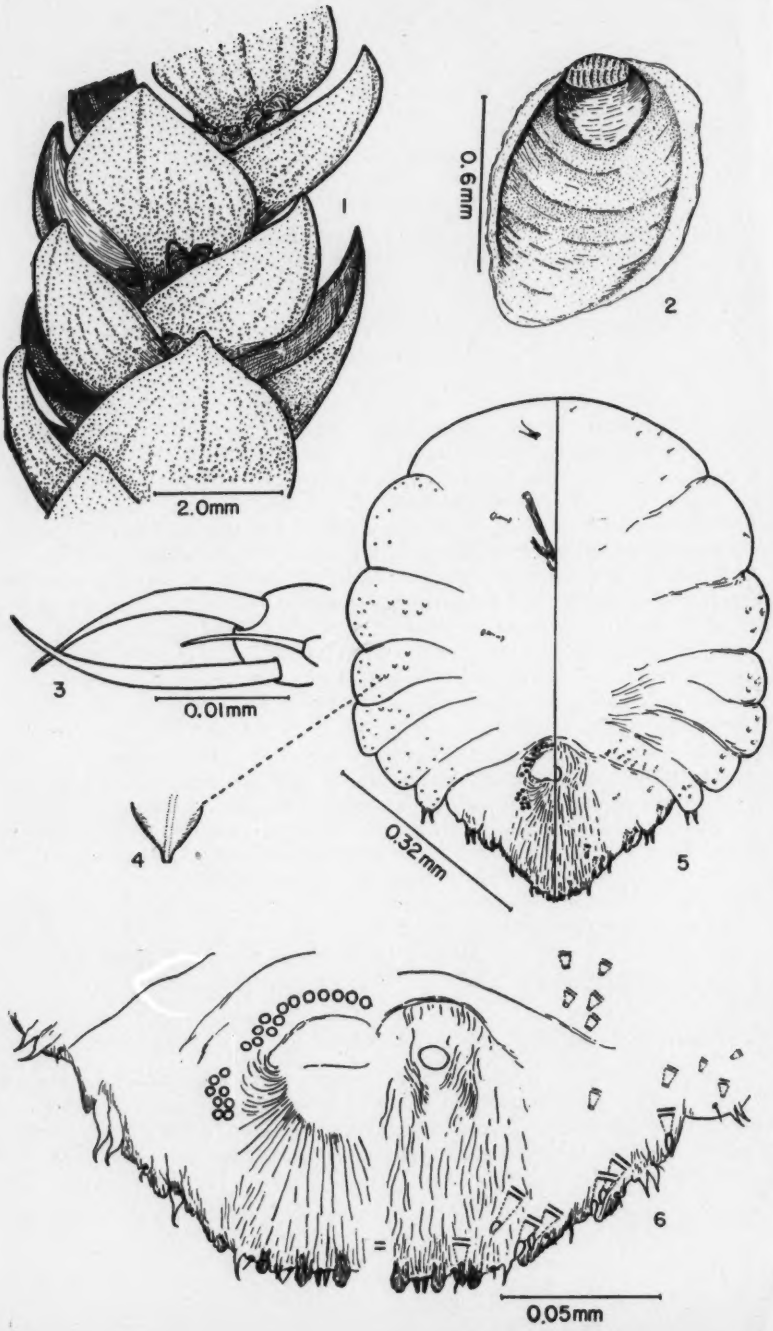
The writers are greatly indebted to Dr. G. F. Ferris for the help that he has given them in the study of the Hawaiian Coccoidea.

Pseudoparlatoria giffardi new species. Figs. 1-6.

This scale occurs in all stages on the leaves of various species of *Araucaria*. It is commonly found in the angles formed by the leaves and stem, and is often not visible from the exterior (fig. 1). On Oahu, *Araucaria* trees are often severely damaged and heavy infestations cause the leaves to turn yellow and die.

[1] Published with the approval of the Director of the Hawaii Agricultural Experiment Station as Technical Paper No. 272.

Plate I



This species differs from typical *Pseudoparlatoria* by having the anal opening located more cephalad of the center of the pygidium and by having the perivulvular pores in three groups instead of the usual four-five groups.

The female scale is elongate-oval, averaging 0.7 mm. in length and 0.5 mm. in width. It is thin, yellow-brown with the exuvia located at the anterior end (fig. 2). The female is turbinate, the mounted specimen measuring 0.66-1.0 mm. in length and 0.4-0.5 mm. in width. The derm is membranous except for the slightly sclerotized pygidium. There are two pairs of lobes on the pygidium, the median pair being slightly the larger. The median pair of lobes is separated by a forked, gland spine characteristic of all known *Pseudoparlatoria*. The fifth and sixth abdominal segments are represented by serrate plates each with two submarginal macroducts. Seven dorsal submarginal macroducts are present on each side of the pygidium (fig. 6). Intermediate dorsal macroducts are fairly numerous, especially along the lateral margins of the abdominal segments. There are a few microducts on the ventral surface on the lateral margins of the prosoma and abdominal segments. In addition to the microducts there are some mammillate glands on the posterior part of the prosoma and on the first and second abdominal segments. The perivulvular pores are arranged in three groups, two lateral and one anteromedian, forming an arch around the anterior margin of the pygidium (fig. 5). The antennal tubercles each have two stout, elongate setae and one short seta (fig. 3).

Type: Manoa Valley, Oahu, T. H. on *Araucaria excelsa,* April, 1951, M. S. Adachi, collector.

Paratypes: Same data as type; also from Barber's Point, Oahu, T. H. on *A. excelsa,* April, 1951, D. E. Hardy, collector; Maunawili, Oahu, T. H. on *A. cunninghamii,* April, 1951, D. E. Hardy, collector; Lanikai, Oahu, T. H. on *A. excelsa,* March, 1952, D. T. Fullaway, collector.

The type slide is being deposited in the United States National Museum. The paratypes are in the following collections: Board of Agriculture and Forestry, B. P. Bishop Museum, Hawaiian Sugar Planters' Association, and the University of Hawaii.

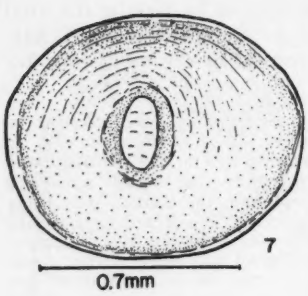
Octaspidiotus araucariae new species. Figs. 7-11.

This species fits closest to *Octaspidiotus subrubescens* (Maskell). Like that species, it has long, pectinate pygidial plates which extend beyond the distal ends of the pygidial lobes and the median lobes are slightly emarginate, not notched, at the apex (fig. 11). It differs from *O. subrubescens* by the lack of perivulvular pores and in the arrangement of the dorsal macroducts. The habitat of this scale is similar to that of *Pseudoparlatoria giffardi;* the two are often found together on the same host plant.

Plate I. **Pseudoparlatoria giffardi** n. sp.

Fig. 1. Habitat of scale on *Araucaria* leaf.
Fig. 2. Scale, enlarged.
Fig. 3. Antennal tubercle.
Fig. 4. Mammillate gland, enlarged.
Fig. 5. Adult female scale.
Fig. 6. Pygidium.

Plate II



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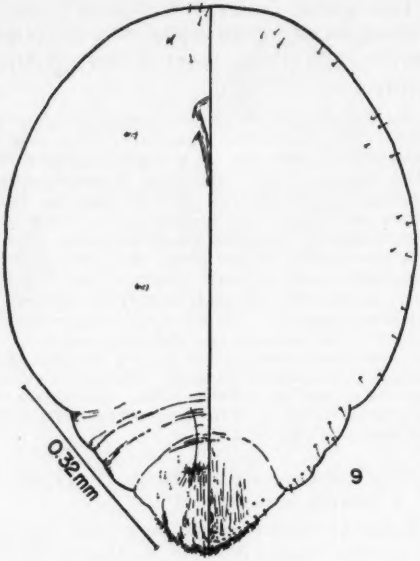

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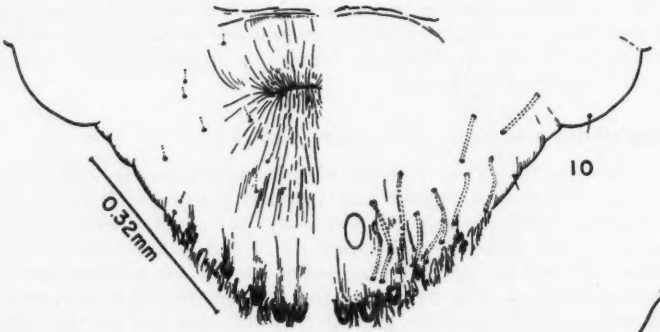

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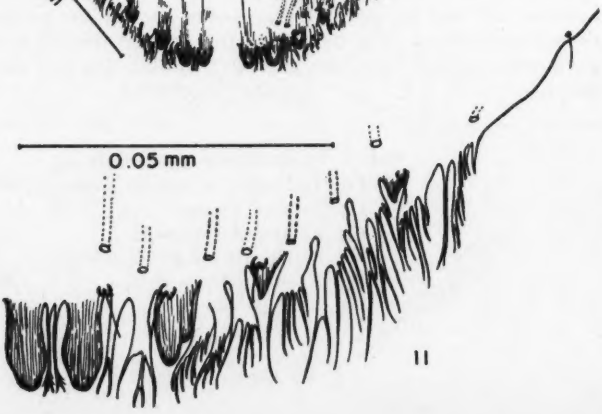

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The female scale is pale yellow to white, somewhat circular, 1.0 mm. by 0.8 mm., with the exuvia slightly eccentric (fig. 7). The body of the female is slightly longer than wide, 0.78 mm. by 0.64 mm. The prosoma is swollen and rounded, and the caudal end of the body is narrowed, the pygidium occupies about one-fifth of the body length. The dorsal lateral margins of the prosoma and postsoma are lined with minute setae. Microducts are present on the lateral margins of the abdominal segments. There are four pairs of lobes present on the pygidium, the median pair is the largest; it is more than twice the length of the third and four times the length of the fourth pair. The lobes of the third and fourth pairs are acute at the distal ends (fig. 11). The pygidial plates are all slender and fringed. The dorsal macroducts are arranged submarginally in a single row. The anal opening is situated on the caudal half of the pygidium and the vulva is located on the anterior half (fig. 10). The antennal tubercles are dentate and each has one seta (fig. 8).

Type: Waipio, Oahu, T. H. on *Araucaria excelsa,* February 1, 1951, J. W. Beardsley, collector.

Paratypes: Same locality as type; Lanikai, Oahu, T. H. March, 1952, D. T. Fullaway, collector.

The type slide is being deposited in the United States National Museum. The paratypes are in the following collections: Board of Agriculture and Forestry, B. P. Bishop Museum, Hawaiian Sugar Planters' Association, and the University of Hawaii.

Plate II. **Octaspidiotus araucariae** n. sp.

Fig. 7. Scale, enlarged.

Fig. 8. Antennal tubercle.

Fig. 9. Adult female scale.

Fig. 10. Pygidium.

Fig. 11. Gland plates of pygidium.

Thysanoptera of Samoa

By FRED A. BIANCHI

EXPERIMENT STATION, H.S.P.A.

Little information is available on the thrips of Samoa. In 1928 Bagnall ("INSECTS OF SAMOA," Part VII) described *Gynaikothrips hopkinsi, Rhaebothrips major* and *Euoplothrips uncinatus* from Upolu; and in 1944 (Occ. Papers Bishop Museum 17:268) Moulton described *Taeniothrips samoensis* from the same island; but no records have appeared in the literature from Tutuila or the other islands of the archipelago. In the present paper the distribution of *R. major* and *T. samoensis* is extended, and twenty-six species (four of them undetermined) are added from the island group as a whole. This brings the total to thirty species; but probably many native species remain to be found in the rich and almost inaccessible forests of the islands, and perhaps some exotics among crops recently introduced into Samoan agriculture.

Among the species known elsewhere and now recorded from Samoa for the first time, the finding of *Erotidothrips mirabilis* Priesner and *Organothrips bianchii* Hood is of special interest. The first because of the vast and unexpected range it evinces for *Erotidothrips;* and the second because *Organothrips* is a pest inseparable from wet taro, and its distribution may provide a clue to the paths of migration of the Polynesian races, to whom taro was the staff of life.

Most of the material upon which this paper is based was collected by O. H. Swezey and E. C. Zimmerman in 1940, in the course of an entomological survey of Samoa. The rest was collected by the author in 1947 and 1951-52, while in charge of the Samoa substation of the H.S.P.A. In the following records the year of collection, unless otherwise stated, will be understood as 1940, and the initials O.H.S., E.C.Z., and F.A.B. will refer to Messrs. Swezey and Zimmerman and to the author, respectively. Types and paratypes will be deposited in the collections of the Bernice P. Bishop Museum and the Experiment Station, H.S.P.A.

Suborder Terebrantia
Superfamily Thripoidea Hood
Family Thripidae Uzel
Subfamily Thripinae Karny

Taeniothrips longistylus Karny

1923—Jour. Siam Soc., 14, pt. 2:99

1929—Greenwood, Proc. Linn. Soc. N. S. Wales 54:350

Described from Siam; known also from Fiji. Eleven females collected by O.H.S. ex *Vigna* sp. at Blunt's Point, Tutuila, on August 17.

Taeniothrips distalis Karny

1913—Archiv fur Naturgeschichte 79 A.H. 2:122

1938—Priesner, Treubia 16:471

Described from Japan; known also in China, Formosa, Java. Seven females collected by E.C.Z. in Apia, Upolu, on June 16, at 2,200 ft. elev. Six females collected by F.A.B. in Vailoatai, Tutuila, on flowers of *Erythrina,* August 15, 1951.

Taeniothrips samoensis Moulton

1944—Occ. Papers B. P. Bishop Mus. 17, No. 2:268

Described from Pago Pago, Tutuila. Also common and sometimes abundant on Upolu. Many collected by O.H.S. and E.C.Z. ex flowers at Afiamalu, Upolu, on June 15, at 2,200 ft. elev. Also found in abundance on "ti" (*Cordyline*) flowers by F.A.B. at Molifanua, Upolu, April, 1947, and on corn tassels at Vailoatai, Tutuila, on several occasions.

Taeniothrips longicaudatus new species. (Plate I, figs. A, B, C.)

Macropterous female about 1.9 mm. long. Light yellowish brown, with abdominal segment 10 and the large setae of 9 and 10 dark; all tarsi and antennal segment 3 nearly colorless; ocellar pigment red.

Head about 0.19 mm. wide across cheeks and 0.15 mm. long excluding costa; a few transverse anastomosing lines distinct near base; cheeks strongly arched; eyes strongly protruding, coarsely faceted and pilose, with about eight facets on the outer edge; ocelli relatively large, the posterior pair near the eyes and caudad of a line through their middle, the anterior one on the flattened vertex which slopes to the short, narrow and acutely notched frontal costa. Interocellar setae 0.041 mm. long, set on the outer tangents between fore and hind ocelli; postocellar setae about 0.024 mm. long and the longest in a series of five which arch back of each eye. Ventral surface of head with two pair of setae near base of antennae nearly attaining apex of second segment. Mouth parts normal to the genus. Antennae with segments 5 to 8 distorted in mounting but apparently characteristic of genus, with stout but light colored setae, with segments 3 and 4 nearly equal in size, amphoriform and bearing bifurcated sense cones with horns about 0.032 mm. long, with the two-segmented style one-fourth or less the length of segment 6.

Prothorax 0.20 mm. long and 0.26 wide, almost rectangular, with straight margins and nearly equally rounded fore and hind angles. Pronotum without distinct striation but with about 20 microsetae more sparsely distributed on the disk than on the sides; posterior angles with paired setae about 0.11. long, a microseta between them, and inward of them, along the posterior margin, three more microsetae on either side of which the innermost is the strongest. Mesoscutum with transverse, more or less anastomosing striae. Metascutum with reticular striation on disk and the usual discal spines on the front margain, the inner pair about equal to a pair on the fore angles and twice as long as the outer pair. Legs normal, finely striate and sparsely beset with microsetae; the front pair considerably stouter than the others; hind tibiae with three stout terminal spines and a series of 14 or 15 much weaker spines along the inner posterior edge. Wings with the same quality and nearly the same intensity of brown as the body except near their bases, where they are almost clear; fore vein with 4

Plate I

A—*Taeniothrips longicaudatus* sp. nov. Head, prothorax of macropterous female.

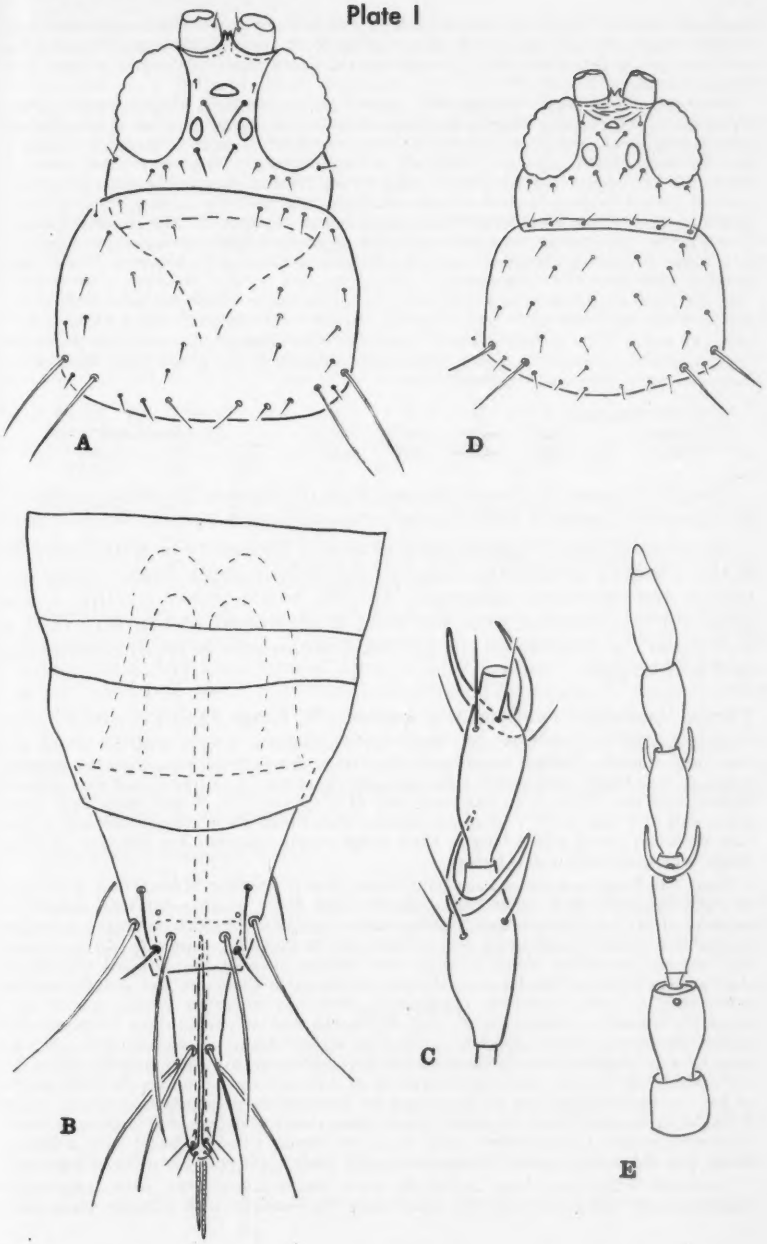
B—*Taeniothrips longicaudatus* sp. nov. Abdominal segments 7, 8, 9, 10 with some setae omitted.

C—*Taeniothrips longicaudatus* sp. nov. Third and fourth antennal segments.

D—*Thrips (Isothrips) modicus* sp. nov. Head, prothorax of macropterous female.

E—*Thrips (Isothrips) modicus* sp. nov. Right antenna of macropterous female without setae.

Plate I



basal and 16 distal setae of which the three endmost are more widely separated than the rest; hind vein with an evenly spaced series of 16 setae which begins opposite the sixth seta of the fore vein and ends opposite the penultimate one; costal margin with about 29 setae.

Abdomen of even width to segment 7, thence conical. Segment 10 split dorsally along five-sixths of its exposed length, but superficially resembling that of a tubuliferous species, long, thin, nearly cylindrical and with one-sixth or more of its length inserted into the much wider segment 9, bearing a rosette of four long, stout setae near the middle of its exposed portion and a much weaker rosette distally. Ovipositor not discernibly curved in dorso-ventral mount, strikingly long and thin, arising seemingly well within segment 7 and considerably surpassing end of segment 10. The usual abdominal setae present but shorter than the respective segments except on segments 9 and 10. One weak wing-retaining spine on each side of tergites 4 to 7. Sternites 3 to 7 with accessory series of 6 to 8 weak setae.

Measurements of female holotype in mm.: Pterothorax length on sides 0.36; pterothorax width in front 0.34; tenth segment length over all 0.22; width at base 0.17, width at end 0.028; eye length 0.102; eye width 0.061; postangular setae on pronotum 0.114; postangular setae on ninth abdominal segment 0.192; longest seta on median rosette of tenth abdominal segment 0.164.

Antennal segments:	1	2	3	4	5	6	7	8
Length	.028	.041	.082	.086		Not measured		
Width	.036	.032	.028	.026				

Described from the female holotype in the Bishop Museum, collected at Afiamalu, Upolu, at 2,200 ft. elevation, on June 8, by E. C. Zimmerman.

While in all other respects this new species appears to be a true member of the *Thrips-Taeniothrips* complex, the unique development of the ovipositor and the tenth abdominal segment would justify erecting a new genus for it. However, until the male is discovered and further light is shed upon the affinities of the species, it seems wise to let the species rest in *Taeniothrips*.

Thrips (Isothrips) modicus new species. (Pl. I, figs. D, E.)

Macropterous female: 0.98 mm. long. Light cinnamon brown, with all tibiae and tarsi buff, the hind tibiae basally a shade darker than the others. Antennal segment 1 and 2 concolorous with head; 2 fading near tip, where it is like 3 and only a shade darker than the tibiae; 4, 5 and basal half of 6 darker than 3 but paler than head; distal half of 6 and all of 7 pale, concolorous with tibiae. Fore wings uniformly brown, pale medianly along whole length; hind wings nearly colorless. Eye pigment carmine. Major setae pale brown to colorless.

Head 1.48 times as wide as long, with cheeks evenly, strongly arched. Eyes with seven or eight facets on their outer edges, sparsely and finely pilose, occupying three-fifths or more of the head length and together more than half its width, but not protruding beyond the cheeks. Ocelli large, about 0.016 mm. in diameter; posterior pair not touching eyes and somewhat ahead of their hind angles; anterior one directed forward on the vertex, which is roundly excavate and declivous to the short and acutely notched inter-antennal costa. Striation conspicuous, with six or seven evenly spaced lines across the occiput coalescing on or near the cheeks, and numerous short confluent lines across the vertex, which cause its surface to appear rough in dorsal view. All head setae minute, shorter than ocellar diameter; interocellars on the outer tangents of the fore and hind ocelli; another pair cephalo-laterad of interocellars and nearer the eyes; a series of four or five arching back of the eyes, with the innermost longest and almost in line with the inner margins of the ocelli. Mouth cone about .8 as long as dorsal head length. Antennae shaped as illustrated; with stout but nearly colorless hairs; with a distinct flange just above the pedicel of segment 3; with sensory pit near distal lip of segment 2.

Prothorax 0.135 mm. long and 0.188 wide, nearly rectangular, with front angles slightly more rounded than the hind ones; the surface with distinct transversely

anastomosing striae and beset with 26-30 setae which leave a bare space along the mid-dorsal line. Outer seta on posterior angle about 0.036 mm. long, inner one about 0.053 mm.; a microseta between them, and inwards from them, along the margin of the pronotum, a series of three, sometimes four, all of equal size. Inner setae on metascutum removed by nearly their length from anterior margin; outer pair on the margin. Legs normal; anterior femora relatively short and thick; hind tibiae with a comb of eleven or twelve spines on the outer hind edge ending in two stout terminal thorns. Costal vein of forewing with about 30 setae; forevein with 3-1 (sometimes 4)-15-1 setae, the distalmost well separated from the others and about its own length from the wing tip; hind vein with 14 to 16, mostly 15, evenly spaced setae nearly in juxtaposition to the 15 of the forevein; scale with five marginal and one discal setae.

Abdomen relatively short and wide; rapidly widened to segment 3, more gradually attenuated from 5 to base of 10. Tergites 2-8 with an indistinct dark line along the fore margin. Sternites without accessory setae. Postmarginal comb on tergite 8 present but ragged, short, difficult to detect. Tergite 10 split along most of its exposed length. Major setae relatively short and stout but pale and inconspicuous; those on segment 9 about 0.061 mm. long; those on segment 10 about 0.082 mm.

Measurements of female holotype in mm.: head length 0.102; head width 0.151; eye length 0.065; eye width 0.045; postocellar setae about 0.012.

Antennal segments:	1	2	3	4	5	6	7	Total
Length	.024	.036	.053	.045	.032	.045	.012	0.247 mm.
Width	.024	.024	.016	.016	.016	.020	.008	

Macropterous male: Like female but smaller (0.81 mm. long). Pale brownish yellow, with only the head distinctly brown and all tibiae and antennal segments 2 and 3 nearly colorless. The arrangement of setae on the veins only approximately as in the female, often irregular. Ventrites 3 to 7 with rather large elliptic tympana, but these sometimes absent or pale and not discernible.

Described from the female holotype and seven female paratypes, and the male allotype and four male paratypes; collected by O.H.S. at 2,200 ft. elevation, Afiamalu, Upolu, June 9. The holotype, allotype and some of the paratypes, are in the Bishop Museum. There is an additional series in alcohol from the same collection.

This species approximates *Isoneurothrips orientalis* Bagnall in the shape of the head and appears to be congeneric with it; but *orientalis* is a larger, darker species, with differently shaped antennae, and conspicuous, nearly black, major setae.

Organothrips bianchii Hood

1940—Proc. Haw. Ent. Soc. 10, (3):423

A ubiquitous pest of wet taro in the Hawaiian Islands; hitherto not known elsewhere, but probably awaiting discovery wherever the host plant is to be found. Not seen on Upolu or Tutuila, where taro is not usually

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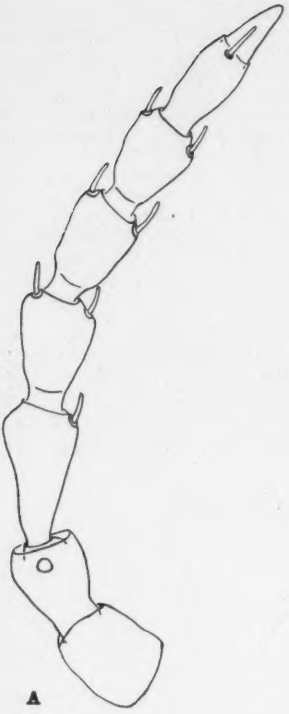
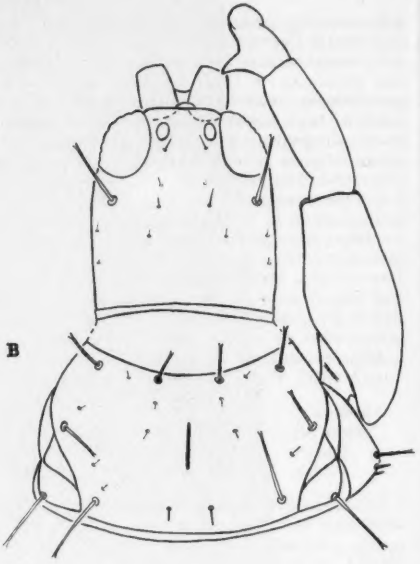
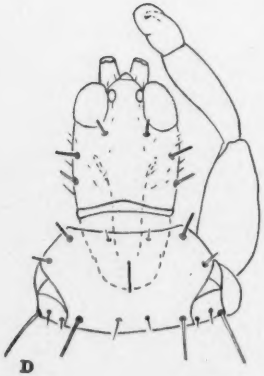
Plate II

A—*Hoplothrips dignus* sp. nov. Right antenna of macropterous female, without setae.
B—*Hoplothrips dignus* sp. nov. Head, prothorax and right foreleg of macropterous female.
C—*Hoplothrips dignus* sp. nov. Tube of macropterous female, without setae.
D—*Gynaikothrips butcharti* sp. nov. Head, prothorax and right foreleg of macropterous female.
E—*Gynaikothrips butcharti* sp. nov. Right antenna of macropterous female, without setae.
F—*Leeuwenia spinosus* Moulton. Right antenna of macropterous male, without setae.

Plate II







grown in water, but collected by F.A.B. on the islands of Anuu and Tau during January, 1952.

Plesiothrips panicus (Moulton)

1929—*Thrips panicus* Moulton; Florida Entomologist 13, (4):61

1936—*Plesiothrips panicus* (Moulton); Hood, Rev. de Entomologia 6, fasc. 2:58

Described from Cuba; listed also from tropical America and Hawaii. Probably synonymous with *P. perplexus* (Beach), which has been recorded in Fiji. Two females collected by F.A.B. on corn ears at Vailoatai, Tutuila, in September, 1947.

Scirtothrips australiae Hood

1919—Proc. Biol. Soc. Wash. 32:75

Described from Australia and not reported elsewhere. One female collected on an ear of corn by F.A.B. at Vailoatai, Tutuila, in September, 1947.

Superfamily Merothripoidea Priesner
Family Merothripidae Hood

Erotidothrips mirabilis Priesner

1939—Rev. Zool. Bot. afr. 32:157

Described from the Belgian Congo and not hitherto reported elsewhere. Three females collected by E.C.Z. on June 7 at Tapatapao, Upolu, at 100 ft. elevation. This remarkable record of presumably discontinuous distribution would be subject to doubt if the Samoan specimens did not fit Priesner's description in every detail.

Suborder Tubulifera Haliday
Family Phlaeothripidae Uzel
Subfamily Phlaeothripinae Priesner
Tribe Hoplothripini Priesner

Hoplothrips dignus new species. (Pl. II, figs. A, B, C.)

Macropterous female: About 2.24 mm. long. Color nearly uniform brown; fore tibiae somewhat lighter, tarsi yellow. Antennal segment 1 concolorous with head; 2 concolorous with 1 at base and outer margin, the rest fading to yellow; 3 yellow, lightly washed with brown on basal third; 4 to 8 successively less yellow and more brown than 3 but 8 always lighter than 1. Wings lightly and almost uniformly washed with brown; with six accessory marginal setae and three nearly colorless sub-basals, of which the proximal is somewhat shorter than the others. These setae, like all other major setae except the distal ones on the tube, are slightly expanded at the end.

Head about 1.2 as long as wide, widest near middle of cheeks; cheeks curving evenly towards eyes and base, which is encircled by narrow collar; dorsum, except ocellar area, sculptured with thin subreticular lines; vertex weakly, roundly swollen, not extending beyond eyes in front. Ocelli conspicuous, about 0.024 mm. in diameter, the front one forwardly directed, the posterior ones near the eyes and cephalad of their midline; a pair of microsetae within the ocellar triangle and one microseta caudad of each hind ocellus. Eyes not protruding; with about nine facets on outer edge; about 0.073 mm. long and 0.053 mm. wide in dorsal aspect; the interval between them greater than their dorsal length; in ventral aspect somewhat smaller and with caudal portion somewhat narrowed. Postocular setae about 0.082 mm. long, 0.020 to 0.028 mm. from the eye and 0.020 mm. from the cheek. Microsetae on cheeks and dorsum few and inconspicuous; a pair somewhat stronger than the others on a line connecting the postoculars. Mouth cone extending about 0.164 mm. beyond the posterior dorsal margin of the head;

labrum dark tipped and just attaining the rounded labium. Antennae as illustrated; with unusually stout segments; bearing few colorless hairs and short, thin, blunt sense cones, of which segment 3 bears one outside, segments 4, 5, 6 one inside and one outside, and segment 7 one dorsally.

Pronotum about .8 as long as head, including coxae about twice as wide as head; with short, weak median apodeme; with weak anastomosing lines near fore and hind margin. The usual setae present; epimerals and postero-marginals about equal to postoculars and longest; antero-marginals shortest, about 0.032 mm. long; coxals darker than others and 0.036 mm. long, with one or two short, stout spines beside them. Pterothorax as wide in front as prothorax and coxae; legs normal, with fore femora moderately incrassate and fore tarsi armed with a stout tooth.

Abdomen about as wide as pterothorax to segment 7, thence rapidly narrowing to base of tube; major setae pale, the longest on segment 9. Tube with sides weakly divergent distally on basal sixth, thence nearly straight and rapidly convergent to end, which is about two-fifths as wide as base. Terminal setae about 0.143 mm. long, brownish basally, clear distally, thin and tapering to a point.

Measurements of female holotype (macropterous) in mm.: Length 2.24; median head length .217; width across eyes .180; width across cheeks .196; pronotum length .172; prothorax width, including coxae, .404; tube length .176; tube width at base .086; tube width at end .036; epimerals .082; postmarginals .082; midlaterals .049; anteroangulars .045; anteromarginals .032; subbasals on forewing .057, .069 and .069.

Antennal segments:	1	2	3	4	5	6	7	8	Total length
Length	.049	.057	.065	.061	.057	.057	.053	.036	0.435 mm.
Width	.041	.041	.041	.041	.041	.036	.028	.016	

Macropterous male: Similar to female in color and size; with much heavier prothorax and incrassate forelegs; the median apodeme of pronotum longer than in female but not reaching either fore or hind margin.

Measurements of male allotype in mm.: Length 2.35; median head length .221; head width .188; length pronotum .233; pronotum width including coxae .395; tube length .180; tube width at base .086; tube width at end .036.

Antennal segments:	1	2	3	4	5	6	7	8	Total length
Length	.057	.057	.069	.065	.053	.057	.057	.036	0.451 mm.
Width	.041	.041	.041	.041	.036	.032	.024	.016	

Described from the female holotype and the male allotype, and one male and ten female paratypes, selected from a colony of about 155 individuals found by O. H. Swezey in leaf rolls of an unidentified plant: Tapatapao, Upolu; July, 1940; elevation 800 ft. The holotype, allotype, and some paratypes are in the Bishop Museum.

The nearest relative of this new species seems to be the Hawaiian *Hoplothrips intermedius* (Bagnall); but *dignus* can be differentiated from all other members of the genus by the unusually stout, pedicellate antennal segments. It also differs from the Hawaiian species of the group in being a leaf roller, the known Hawaiian species all forming colonies under bark or in the wood of rotten logs.

Hoplothrips undet. sp.

One apterous male and two macropterous females which appear to be of the same species were collected by E.C.Z. on August 29 at Pioa, Tutuila, 1,700 ft. elevation.

Cryptothrips undet. sp.

One macropterous female, Utulei, 500 to 700 ft. elevation, August 18; one macropterous female, Amouli, 400 to 800 ft. elevation, August 2; one

macropterous male, Fagatogo, 900 ft. elevation, August 25; all by E.C.Z. on Tutuila.

Symphiothrips undet. sp.

One macropterous female, Afiamalu, Upolu, 2,100 ft. elevation, June 13, by E.C.Z.; one macropterous female, Vailoatai, Tutuila, 100 ft. elevation, in an ear of green corn, September, 1947, by F.A.B.

The identity of this, and the two preceding species remains to be positively established and will be dealt with at a future date.

Gynaikothrips imitans Karny

1916—Zs. wiss. Insektbiol. 12:88

Described and known only from Java. Five females and four males collected by E.C.Z. in Afiamalu, Upolu, on July 10, at 2,000 ft. elev.; and one male on August 25, at 900 ft. elev., in Fagatogo, Tutuila.

Gynaikothrips magnafemora Moulton

1944—Occ. Papers. B. P. Bishop Museum 17, No. 22:272

Described from Fiji. One male collected by E.C.Z. at Pioa, Tutuila, on August 29, at 1,700 ft. elevation.

Gynaikothrips butcharti new species. (Pl. II, figs. D, E.)

Macropterous female: About 3.14 mm. long. Color by transmitted light: abdomen, thorax, head, antennal segment one, black; foretibiae, the other legs at the joints, and all the tarsi brown. Antennal segment 2 concolorous with 1 on basal half and inner margin, lighter in rest of segment; 3 gradually darker from pale brown in basal half to dark brown distally, where it is concolorous with the rest of antennae. Wings washed with brown; forewing with irregular median cloud on second and third fifths; hind wing with narrow median cloud on basal three-fifths. Forewing usually with 25 accessory hairs, sometimes with as few as 16; with three blunt, pale brown subbasals about 0.069 mm. long.

Head about 1.26 as long as greatest width, which is on anterior fifth of cheeks. Cheeks nearly straight and parallel, weakly narrowed back of eyes and weakly convergent from basal fourth to slight collar-like thickening as base of head; with three to five blunt thorn-like genal setae which may approximate the postoculars in size. Eyes finely faceted; a third as long as head and together occupying more than half its width; their caudal margins weakly rounded in both dorsal and ventral aspect. Vertex produced conically; bearing anterior ocellus forwardly directed and just attaining the shallow notch of the inter-antennal costa. A minute seta stands on the vertex at either side of the anterior ocellus, a similar seta on the angle of the vertex with the eye, and a somewhat stronger seta back of each posterior ocellus. The first postoculars are about 0.043 mm. long, in line with the inner margins of the eyes and about 0.020 mm. from their hind margins. The second postoculars are about 0.060 mm. long, almost on the cheeks and about 0.061 mm. from the eyes. Striation is fine, transversely confluent except in the ocellar region where it is reticulate. Mouth cone heavy, broadly rounded, not surpassed by labrum, reaching to about middle of prosternum. Antennae as illustrated, with weak, acute sense cones, and pale hairs.

Prothorax about .65 the length of head and exclusive of coxae not quite twice as wide as long; with weak and incomplete median thickening, scattered microsetae, and confused strial pattern which is reticulate on disk but not so peripherally. Major setae pale brown, tapering to blunt or weakly expanded ends; their lengths in mm. as follows: anteroangulars 0.034; midlaterals 0.060; epimerals 0.137; posteromarginals 0.086; coxals 0.060; anteromarginals minute. Forelegs unarmed, somewhat incrassate, with femora wider than interocular space. Meso- and metanotum and first abdominal tergum distinctly sculptured medianly in reticular pattern.

Abdomen evenly reduced to middle of segment 8 which is abruptly narrowed in posterior half. Tergites 1 to 6 bear from five to eight sharp thorns grouped near each anterior angle. Sternites 2 to 7 bear a transverse series (10 to 20) of short intermarginal setae. Posteroangular setae of segment 9 pointed and about half as long as tube. Tube characteristic of genus; expanding on basal fifth and narrowed on distal fifth; terminal hairs half as long as tube.

Measurements of female holotype in mm.: Body length 3.14; head length 0.326; width back of eyes 0.258; dorsal eye length 0.111; dorsal eye width 0.077; prothorax length 0.215; prothorax width 0.412; tube length 0.344; tube width at base 0.103; tube width at end 0.051; setae on segment 9 and tube approximately 0.232; width of anterior femora 0.086; interocular space 0.086.

Antennal segments:	1	2	3	4	5	6	7	8	Total length
Length	.043	.060	.129	.103	.103	.094	.068	.043	0.643 mm.
Width	.043	.034	.034	.043	.043	.034	.025	.017	

Macropterous male: Color as in female; distinguished from it by a strong spur on the basal segment of foretarsus and because the outer posteroangular seta of abdominal segment 9 is always thornlike and only about half as long as the inner seta. Quite variable as to size and development, the smaller individuals approximating the female and the larger ones attaining more than 4 mm. in length when distended.

Head of allotype relatively longer and narrower than in female, with stronger and more numerous genal thorns, with cheeks straight and barely convergent from eye to basal fifth and, as in female, more strongly narrowed thence to collar-like base. Prothorax exclusive of coxae about 0.362 mm. long and 0.569 mm. wide, with complete, strong median and anteromarginal thickening; with strial pattern forming a more or less distinct whorl at each quadrant of the pronotum. Forefemora five-sixths as wide as head and other parts of forelegs correspondingly developed.

Measurements of male allotype (macropterous) in mm.: Overall length 4.17; head length 0.378; head width 0.258; dorsal eye length 0.137; dorsal eye width 0.086; first postoculars 0.051; second postoculars 0.051; epimerals 0.129; posteromarginals 0.051; anteroangulars 0.043; tube length 0.387; tube width at end 0.060; tube width at base 0.111; posteromarginal seta on ninth abdominal segment 0.215; posteroangular on the same 0.086.

Antennal segments:	1	2	3	4	5	6	7	8	Total length
Length	.060	.060	.146	.129	.120	.103	.077	.043	0.738 mm.

Described from the female holotype and two female paratypes, and the male allotype and 23 male paratypes, all collected by F.A.B. on leaves of a *Psychotria* sp.; Tafuna Forest, Tutuila; December 17, 1951. Named in honor of David Butchart, Director of Agriculture, American Samoa, a friend to whom the author is indebted for many favors. The holotype, allotype, and some paratypes are in the H.S.P.A. collection.

This species is apparently related to the homogeneous group of the genus which Moulton has described from Fiji; but comparison with Moulton's types in the Bishop Museum shows this to be a larger and

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Plate III

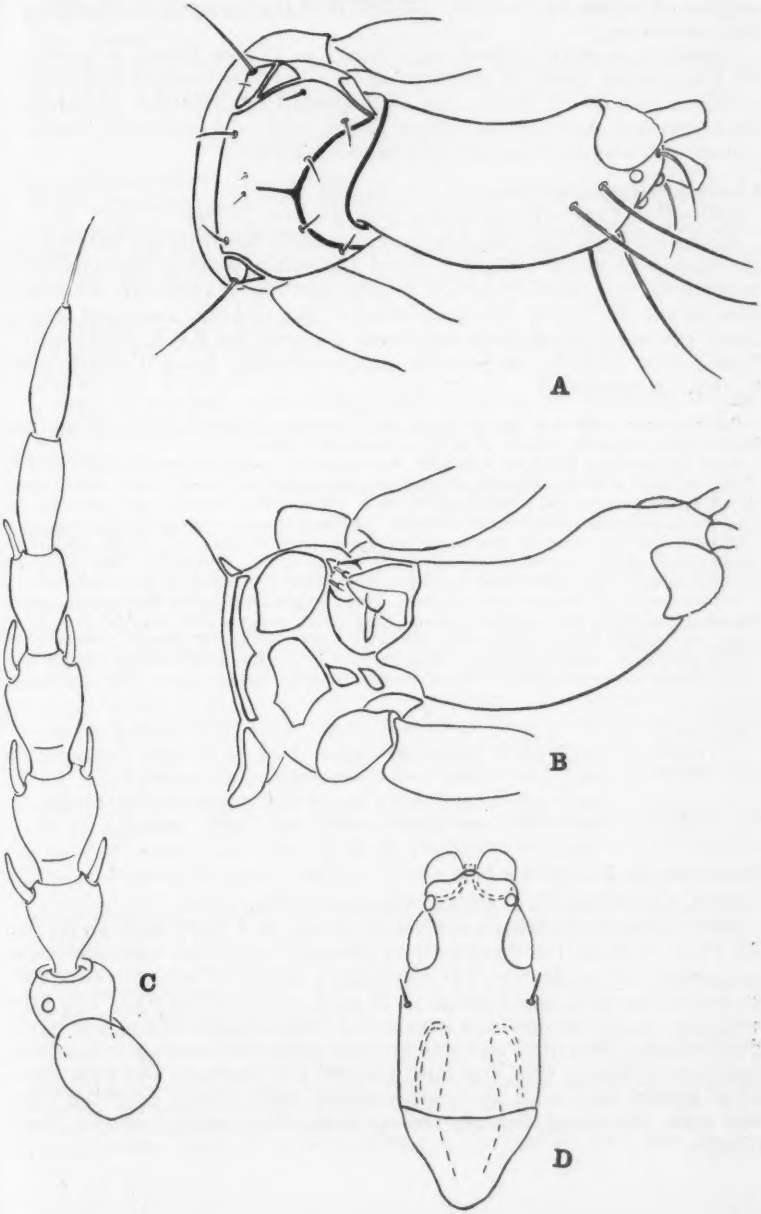
A—*Docessissophothrips magnificus* sp. nov. Dorso-lateral view of head and prothorax of macropterous female.

B—*Docessissophothrips magnificus* sp. nov. Ventro-lateral view of head and prothorax of macropterous female.

C—*Chelaeothrips fuscus* Moulton. Right antenna of macropterous female, without setae.

D—*Chelaeothrips fuscus* Moulton. Dorsal view of head of macropterous female, without microsetae.

Plate III



stronger species than any from Fiji. It is perhaps nearest to *Gynaikothrips magnus* Moulton, but is easily distinguished from *magnus* by its entirely dark antennae.

About 30 or 40 individuals were found at Tafuna loosely grouped on six new, tender leaves of the host plant. They had been feeding on the under surface of the leaves, and these showed small brown, pustule-like scars, and in some cases had begun to roll their edges inwardly, forming cylinders in which the thrips had placed a few eggs.

Chelaeothrips fuscus Moulton (Pl. III, figs. C, D.)

1944—Occ. Papers B. P. Bishop Mus. 17, No. 22:296

Described from Fiji from one apterous male. Study of the holotype in the Bishop Museum collection shows the vertex swollen and produced beyond the eyes, much as in the female, and not as shown in Moulton's illustration. Following is a description of the hitherto unknown female based on two macropterous specimens collected by E.C.Z. at Afiamalu, Upolu, elev. 2,200 ft., on June 25, and on Matafao Trail, Tutuila, 2,000 ft. elev., on August 13.

Color, nearly uniformly brown; tarsi and foretibiae somewhat lighter. Wings uniformly light yellowish brown; with 18 to 24 double cilia.

Head as described for male but with vertex swollen, produced nearly rectangularly ahead of eyes, and bearing the anterior ocellus directed forward and overhanging tip of inter-antennal costa. Hind ocelli large, wide apart, inserted dorso-laterally on the vertex, just above front angles of eyes. Antennae shaped as illustrated.

Thorax and abdomen as described for female. Apical setae on middle and hind tibiae thick, blunt, thornlike; tarsal claws conspicuously developed; both setae on posterior angles of segment nine hair-like, nearly colorless, about as long as tube.

Measurements of two specimens in mm.: Head length on midline 0.387 (.387); cheek length 0.246 (.246); head width at base 0.213 (.221); head width back of eyes 0.200 (.192); eye length 0.106 (.102); eye width 0.057 (.049); prothorax length overall 0.438 (.430); prothorax width including coxae 0.593 (.567); tube length 0.301 (.301); tube width across base 0.164 (.159); tube width at tip 0.061 (.061).

Antennal segments:	1	2	3	4	5	6	7	8	Total
Length	.065	.061	.069	.069	.073	.069	.073	.086	0.565 mm.
Width	.061	.053	.061	.065	.053	.036	.024	.020	
Length	.061	.061	.065	.073	.077	.069	.073	.090	0.569 mm.
Width	.061	.053	.061	.061	.053	.036	.024	.020	

Horistothrips fuscus Moulton

1944—Occ. Papers B. P. Bishop Museum 17, No. 22:293.

One macropterous female collected by E.C.Z. at 1,700 ft. elev. on August 29, Pioa, Tutuila. Comparison with Moulton's apterous holotype leaves no question of its identity. The forewings bear eleven accessory cilia and, under high magnification, seem to be scaly on the distal half. The hind wings are nearly colorless but have a dark median line running out to the distal fourth. The hind and middle legs—which are lacking in the holotype—are relatively thin and long, colored like the body but with somewhat lighter tarsi, with each tarsus armed with a sharp recurved claw, and with the tibiae bearing several long, thin, nearly colorless hairs distally.

Tribe Plectrothripini Priesner

Plectrothrips collaris Bagnall

1909—Trans. Nat. Hist. Soc. Newcastle 3:531.

Described from the island of Nias, Sumatra. One macropterous female collected by E.C.Z. at Tapatapao, Upolu, on June 7, at 1,000 ft. elev.

Tribe Haplothripini Priesner

Haplothrips gowdeyi (Franklin)

1908—*Anthothrips gowdeyi* Franklin—Proc. U. S. Nat. Mus. 33:724.

Cosmopolitan. Six females collected by E.C.Z. on corn ears in Sinaele, Upolu, on July 27, at 1,400 ft. elev.; eight females on the same host at Vailoatai, Tutuila, by F.A.B. in September, 1947.

Karnyothrips flavipes (Jones)

1912—*Anthothrips flavipes* Jones—Tech. Ser. 23, Pt. 1, Bur. Ent. U. S. Dept. Agr. p. 18.

Known in America, West Indies, Hawaii, Sumatra; probably tropicopolitan. One female collected by E.C.Z. on August 11 at the Naval Station, Tutuila.

Tribe Hystricothripini Priesner

Leeuwenia spinosus Moulton (Plate II, fig. F.)

1944—Occ. Papers B. P. Bishop Mus. 17, No. 22:299

Leeuwenia fijiensis Moulton. 1944—L.c., following *L. spinosus* on the same page. **New synonym.**

Comparison of the holotypes, now in the Bishop Museum, leaves no question of the above synonymy. Moulton's illustration of two subequal setae on the posterior prothoracic angles of his *fijiensis* is not accurate. In both holotypes there is only one blunt seta (the epimeral) with a microseta immediately cephalad of it. Other differences indicated in the descriptions are due to poor mounting of the specimens. The real shape of the head in both holotypes is much as described for *fijiensis;* the chaetotaxy of the prothorax as illustrated for *spinosus.*

What appears to be a macropterous male of this species was collected by E.C.Z. at Afiamalu, Upolu, 2,200 ft. elevation, on June 8. A description of the male based on this specimen follows:

Measurements in mm.: Overall length 3.62; head length on sides 0.387; head width at base 0.309; head width across middle of eyes 0.249; prothorax length 0.206; prothorax width 0.447; epimeral seta 0.057; eye length 0.120; eye width 0.086; tube length 0.995; tube width at base 0.129; tube width at end 0.060.

Color yellowish brown, with head, prothorax, sides of pterothorax, and antennal segments 1 and 2 darkest and concolorous. Tarsi and antennal segments 3 to 8 yellowish, with segment 3 lightest and 4 to 8 progressively a little darker.

Head narrower across eyes than at base, with densely thorny cheeks nearly straight, weakly convergent, conspicuously constricted behind eyes. Eyes about half as long as the cheeks and about .7 as wide as long; their inner margins straight and converging posteriorly. Ocelli relatively large; posterior pair just ahead of a line across middle of eyes and nearly contiguous to them; anterior ocellus on tip of produced vertex, overhanging antennal insertion but not attaining tip of inter-antennal costa. Striation

rough, mostly reticular. Antennae shaped as illustrated, inserted on the tangent of both eyes; inter-antennal costa about half as wide as first segment and weakly concave.

Prothorax more than twice as wide as long, weakly concave in front and weakly convex in back; with sides weakly curved and convergent anteriorly; with smoother surface than head; with many microsetae on disk but only one large blunt seta on the epimera. Forefemora incrassate. Foretarsi with a minute curved tooth on inner edge of basal segment. Wings lightly washed with brown; their surface under high magnification apparently roughened with scales and undulating lines which are more conspicuous basally than distally.

Abdomen as described for female; tergite nine with about twenty conspicuous microsetae unevenly distributed over whole surface; tergite eight with a group of about ten on each side, and twelve concentrated in two uneven transverse rows near middle. Tube sparsely setose and about 2.5 as long as head.

Leeuwenia undet. sp.

One macropterous male collected in the same locality as the preceding by E.C.Z. on June 30. Possibly this also is *spinosus*. In most respects it is like that species, but it is smaller than Moulton's specimens or mine, and differs in the shape of the antennae and in the possession of a large tooth on the basal segment of the foretarsus.

Tribe Phlaeothripini Priesner

Phlaeothrips claratibia Moulton

1937—Proc. Haw. Ent. Soc. 9, (3):414

1947—Pan-Pac. Entomologist 23, (4):175

Known from Hawaii and New Guinea. E.C.Z. collected one female at Afiamalu, Upolu, 2,100 ft. elev., on July 13; one female at Tapatapao, Upolu, 800 ft. elev., on July 20; and six females and five males at Falefa Falls, Upolu, on June 3.

Tribe Docessissophothripini Priesner

Docessissophothrips magnificus new species. (Pl. III, figs. A, B.)

Macropterous female: Length fully extended 7 mm. Color by transmitted light: head and abdominal segments 3-10 dark brown, nearly black; prothorax, pterothorax, abdominal segments 1-3, and coxae lighter brown; legs yellowish brown. Antennal segments 1 and 6-8 concolorous with prothorax; 2 yellowish medianly and distally; 3 yellow tinged with brown on distal third; 4 yellow medianly, tinged brown basally and distally; 5 like 6-8 but lighter on basal third. Forewings washed with brown, fading to nearly clear in distal and basal sixths. Hind wings fading on distal sixth; with a clear band between anterior margin and midline, which are darker than rest of wing. Marginal cilia, including about 50 accessories, concolorous with wing. Subbasal setae, like all body setae, clear or nearly so; evenly spaced and increasing in size to the distal one which is 0.068 mm. long.

Head about 2.5 times as long as wide; strongly convex above and concave below; with a strong basal carina dorsally, the vertex flattened between the eyes, the front ocellus forwardly directed, the hind ocelli nearly contiguous with the eyes and just cephalad of a line through their middle. Eyes finely faceted; in dorsal view nearly oval, protruding, occupying about one-sixth of head length; in lateral view with an angular caudo-ventral extension. Anteocellar setae long and conspicuous, well ahead of anterior ocellus and near eye margin. Postocellars near to ocelli and minute. Anterior postoculars inward of inner eye margin and slightly back of their hind margin; second postoculars about 0.103 mm. caudad of the first and on the same longitudinal line. Antennae about as long as head; inserted ventrally and with narrow inter-antennal costa just visible from above in dorsal view; with pale, inconspicuous hairs and short, acute sense cones no

longer than one-quarter the length of the corresponding segments. Mouth cone broadly rounded; reaching to about middle of prosternum.

Pronotum deeply concave and strongly carinate on front margin; with weak, incomplete median apodeme. Epimera separated by wide depression from pronotum, nearly tubercular and bearing the long, thin, pale epimeral seta at the summit. Other pronotal setae small and inconspicuous.

Legs rather long and thin, with laterally prominent coxae. The fore femora incrassate but not as thick as the head. Pterothorax nearly quadrate, only slightly narrowed caudally. Abdomen of almost equal width to segment 8, which is angularly constricted to the much narrower 9. Posteroangular setae colorless and relatively thin but as long or longer than corresponding segments; the longest on segment 9. Tube .7 as long as head; gradually narrowed from base to near the end, where it is suddenly roundly constricted to the weak terminal hairs, of which the longer are 0.164 mm. long.

Measurements of female holotype in mm.: Head length about 1.02; head thickness dorso-ventrally about 0.425; anterocellars 0.17; postoculars 0.306; epimerals 0.17; pronotum length 0.17; prothorax width without coxae 0.595; pterothorax width in front 0.816; pterothorax length on side 0.850; tube length 0.714; tube width at base 0.204; tube width at end 0.085.

Antennal segments:	1	2	3	4	5	6	7	8	Total
Length	.102	.136	.238	.136	.136	.119	.085	.085	1.037 mm.
Width	.085	.068	.059	.068	.059	.051	.042	.034	

Macropterous male: Color as in female; size smaller, only 6 mm. long. Head smaller in relation to body and less strongly arched than in male; prothorax longer. Abdomen reduced gradually from second segment. Basal segment of foretarus produced inwardly into a stout spur.

Measurements of male allotype in mm.: Head length 0.788; head width across cheeks 0.323; tube length 0.595; tube width at base 0.153; tube width at end 0.085; width of forefemora 0.255; pronotum length 0.258; prothorax width including coxae 0.680; pterothorax width 0.799; pterothorax length 0.595.

Described from the female holotype collected at Afiamalu, Upolu (elev. 2,200 ft.) on July 10, 1940, by E. C. Z., and the male allotype collected in the same locality at 2,100 ft. on June 13. Both of these are in the Bishop Museum.

Judging from descriptions this species seems to resemble *D. adiaphorus* Karny in color and shape. But it differs from *adiaphorus* in its much greater size; in the possession of long anteocellars; in the relative lengths of the setae on the prothorax and the subbasals on the forewings; in the size and shape of the antennal sense cones; and in having about 50 double hairs on the forewings instead of 17.

Subfamily Megathripinae Priesner
Tribe Compsothripini Priesner

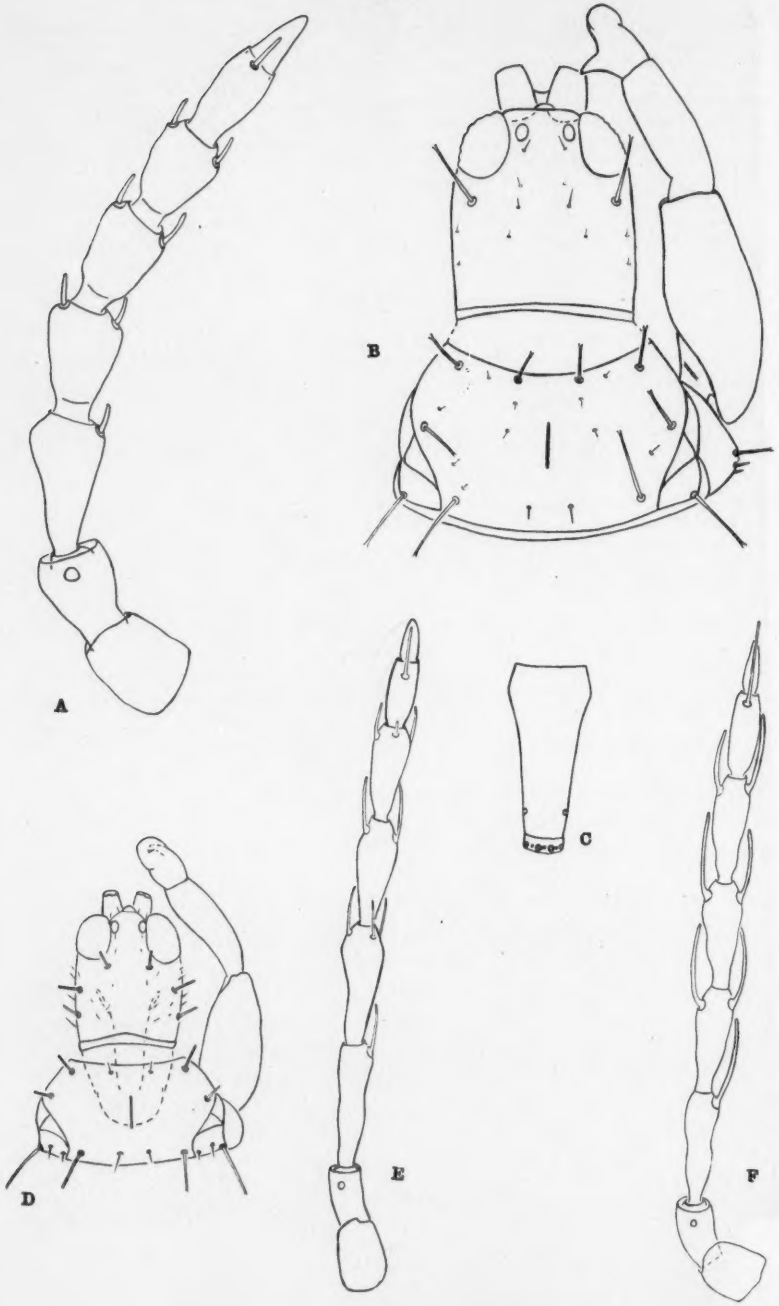
Dichaetothrips setidens (Moulton)

1928—*Mesothrips setidens* Moulton—Proc. Haw. Ent. Soc. 7, (1):129

1944—*Dichaetothrips setidens* (Moulton)—Occ. Papers B. P. Bishop Museum 17, No. 22:308

Known in Hawaii, Fiji, Tuamotus, Mangareva. E.C.Z. collected one female in Tapatapao, Upolu, on July 13, at 1,000 ft. elev., and one female in Swain's Island on August 20; and F.A.B. one female at Vailoatai, Tutuila, in 1947.

Plate II



grown in water, but collected by F.A.B. on the islands of Anuu and Tau during January, 1952.

Plesiothrips panicus (Moulton)

1929—*Thrips panicus* Moulton; Florida Entomologist 13, (4) :61

1936—*Plesiothrips panicus* (Moulton) ; Hood, Rev. de Entomologia 6, fasc. 2:58

Described from Cuba; listed also from tropical America and Hawaii. Probably synonymous with *P. perplexus* (Beach), which has been recorded in Fiji. Two females collected by F.A.B. on corn ears at Vailoatai, Tutuila, in September, 1947.

Scirtothrips australiae Hood

1919—Proc. Biol. Soc. Wash. 32:75

Described from Australia and not reported elsewhere. One female collected on an ear of corn by F.A.B. at Vailoatai, Tutuila, in September, 1947.

Superfamily Merothripoidea Priesner
Family Merothripidae Hood

Erotidothrips mirabilis Priesner

1939—Rev. Zool. Bot. afr. 32:157

Described from the Belgian Congo and not hitherto reported elsewhere. Three females collected by E.C.Z. on June 7 at Tapatapao, Upolu, at 100 ft. elevation. This remarkable record of presumably discontinuous distribution would be subject to doubt if the Samoan specimens did not fit Priesner's description in every detail.

Suborder Tubulifera Haliday
Family Phlaeothripidae Uzel
Subfamily Phlaeothripinae Priesner
Tribe Hoplothripini Priesner

Hoplothrips dignus new species. (Pl. II, figs. A, B, C.)

Macropterous female: About 2.24 mm. long. Color nearly uniform brown; fore tibiae somewhat lighter, tarsi yellow. Antennal segment 1 concolorous with head; 2 concolorous with 1 at base and outer margin, the rest fading to yellow; 3 yellow, lightly washed with brown on basal third; 4 to 8 successively less yellow and more brown than 3 but 8 always lighter than 1. Wings lightly and almost uniformly washed with brown; with six accessory marginal setae and three nearly colorless sub-basals, of which the proximal is somewhat shorter than the others. These setae, like all other major setae except the distal ones on the tube, are slightly expanded at the end.

Head about 1.2 as long as wide, widest near middle of cheeks; cheeks curving evenly towards eyes and base, which is encircled by narrow collar; dorsum, except ocellar area, sculptured with thin subreticular lines; vertex weakly, roundly swollen, not extending beyond eyes in front. Ocelli conspicuous, about 0.024 mm. in diameter, the front one forwardly directed, the posterior ones near the eyes and cephalad of their midline; a pair of microsetae within the ocellar triangle and one microseta caudad of each hind ocellus. Eyes not protruding; with about nine facets on outer edge; about 0.073 mm. long and 0.053 mm. wide in dorsal aspect; the interval between them greater than their dorsal length; in ventral aspect somewhat smaller and with caudal portion somewhat narrowed. Postocular setae about 0.082 mm. long, 0.020 to 0.028 mm. from the eye and 0.020 mm. from the cheek. Microsetae on cheeks and dorsum few and inconspicuous; a pair somewhat stronger than the others on a line connecting the postoculars. Mouth cone extending about 0.164 mm. beyond the posterior dorsal margin of the head;

labrum dark tipped and just attaining the rounded labium. Antennae as illustrated; with unusually stout segments; bearing few colorless hairs and short, thin, blunt sense cones, of which segment 3 bears one outside, segments 4, 5, 6 one inside and one outside, and segment 7 one dorsally.

Pronotum about .8 as long as head, including coxae about twice as wide as head; with short, weak median apodeme; with weak anastomosing lines near fore and hind margin. The usual setae present; epimerals and postero-marginals about equal to postoculars and longest; antero-marginals shortest, about 0.032 mm. long; coxals darker than others and 0.036 mm. long, with one or two short, stout spines beside them. Pterothorax as wide in front as prothorax and coxae; legs normal, with fore femora moderately incrassate and fore tarsi armed with a stout tooth.

Abdomen about as wide as pterothorax to segment 7, thence rapidly narrowing to base of tube; major setae pale, the longest on segment 9. Tube with sides weakly divergent distally on basal sixth, thence nearly straight and rapidly convergent to end, which is about two-fifths as wide as base. Terminal setae about 0.143 mm. long, brownish basally, clear distally, thin and tapering to a point.

Measurements of female holotype (macropterous) in mm.: Length 2.24; median head length .217; width across eyes .180; width across cheeks .196; pronotum length .172; prothorax width, including coxae, .404; tube length .176; tube width at base .086; tube width at end .036; epimerals .082; postmarginals .082; midlaterals .049; anteroangulars .045; anteromarginals .032; subbasals on forewing .057, .069 and .069.

Antennal segments:	1	2	3	4	5	6	7	8	Total length
Length	.049	.057	.065	.061	.057	.057	.053	.036	0.435 mm.
Width	.041	.041	.041	.041	.041	.036	.028	.016	

Macropterous male: Similar to female in color and size; with much heavier prothorax and incrassate forelegs; the median apodeme of pronotum longer than in female but not reaching either fore or hind margin.

Measurements of male allotype in mm.: Length 2.35; median head length .221; head width .188; length pronotum .233; pronotum width including coxae .395; tube length .180; tube width at base .086; tube width at end .036.

Antennal segments:	1	2	3	4	5	6	7	8	Total length
Length	.057	.057	.069	.065	.053	.057	.057	.036	0.451 mm.
Width	.041	.041	.041	.041	.036	.032	.024	.016	

Described from the female holotype and the male allotype, and one male and ten female paratypes, selected from a colony of about 155 individuals found by O. H. Swezey in leaf rolls of an unidentified plant: Tapatapao, Upolu; July, 1940; elevation 800 ft. The holotype, allotype, and some paratypes are in the Bishop Museum.

The nearest relative of this new species seems to be the Hawaiian *Hoplothrips intermedius* (Bagnall); but *dignus* can be differentiated from all other members of the genus by the unusually stout, pedicellate antennal segments. It also differs from the Hawaiian species of the group in being a leaf roller, the known Hawaiian species all forming colonies under bark or in the wood of rotten logs.

Hoplothrips undet. sp.

One apterous male and two macropterous females which appear to be of the same species were collected by E.C.Z. on August 29 at Pioa, Tutuila, 1,700 ft. elevation.

Cryptothrips undet. sp.

One macropterous female, Utulei, 500 to 700 ft. elevation, August 18; one macropterous female, Amouli, 400 to 800 ft. elevation, August 2; one

macropterous male, Fagatogo, 900 ft. elevation, August 25; all by E.C.Z. on Tutuila.

Symphiothrips undet. sp.

One macropterous female, Afiamalu, Upolu, 2,100 ft. elevation, June 13, by E.C.Z.; one macropterous female, Vailoatai, Tutuila, 100 ft. elevation, in an ear of green corn, September, 1947, by F.A.B.

The identity of this, and the two preceding species remains to be positively established and will be dealt with at a future date.

Gynaikothrips imitans Karny

1916—Zs. wiss. Insektbiol. 12:88

Described and known only from Java. Five females and four males collected by E.C.Z. in Afiamalu, Upolu, on July 10, at 2,000 ft. elev.; and one male on August 25, at 900 ft. elev., in Fagatogo, Tutuila.

Gynaikothrips magnafemora Moulton

1944—Occ. Papers. B. P. Bishop Museum 17, No. 22:272

Described from Fiji. One male collected by E.C.Z. at Pioa, Tutuila, on August 29, at 1,700 ft. elevation.

Gynaikothrips butchartí new species. (Pl. II, figs. D, E.)

Macropterous female: About 3.14 mm. long. Color by transmitted light: abdomen, thorax, head, antennal segment one, black; foretibiae, the other legs at the joints, and all the tarsi brown. Antennal segment 2 concolorous with 1 on basal half and inner margin, lighter in rest of segment; 3 gradually darker from pale brown in basal half to dark brown distally, where it is concolorous with the rest of antennae. Wings washed with brown; forewing with irregular median cloud on second and third fifths; hind wing with narrow median cloud on basal three-fifths. Forewing usually with 25 accessory hairs, sometimes with as few as 16; with three blunt, pale brown subbasals about 0.069 mm. long.

Head about 1.26 as long as greatest width, which is on anterior fifth of cheeks. Cheeks nearly straight and parallel, weakly narrowed back of eyes and weakly convergent from basal fourth to slight collar-like thickening as base of head; with three to five blunt thorn-like genal setae which may approximate the postoculars in size. Eyes finely faceted; a third as long as head and together occupying more than half its width; their caudal margins weakly rounded in both dorsal and ventral aspect. Vertex produced conically; bearing anterior ocellus forwardly directed and just attaining the shallow notch of the inter-antennal costa. A minute seta stands on the vertex at either side of the anterior ocellus, a similar seta on the angle of the vertex with the eye, and a somewhat stronger seta back of each posterior ocellus. The first postoculars are about 0.043 mm. long, in line with the inner margins of the eyes and about 0.020 mm. from their hind margins. The second postoculars are about 0.060 mm. long, almost on the cheeks and about 0.061 mm. from the eyes. Striation is fine, transversely confluent except in the ocellar region where it is reticulate. Mouth cone heavy, broadly rounded, not surpassed by labrum, reaching to about middle of prosternum. Antennae as illustrated, with weak, acute sense cones, and pale hairs.

Prothorax about .65 the length of head and exclusive of coxae not quite twice as wide as long; with weak and incomplete median thickening, scattered microsetae, and confused strial pattern which is reticulate on disk but not so peripherally. Major setae pale brown, tapering to blunt or weakly expanded ends; their lengths in mm. as follows: anteroangulars 0.034; midlaterals 0.060; epimerals 0.137; posteromarginals 0.086; coxals 0.060; anteromarginals minute. Forelegs unarmed, somewhat incrassate, with femora wider than interocular space. Meso- and metanotum and first abdominal tergum distinctly sculptured medianly in reticular pattern.

Abdomen evenly reduced to middle of segment 8 which is abruptly narrowed in posterior half. Tergites 1 to 6 bear from five to eight sharp thorns grouped near each anterior angle. Sternites 2 to 7 bear a transverse series (10 to 20) of short intermarginal setae. Posteroangular setae of segment 9 pointed and about half as long as tube. Tube characteristic of genus; expanding on basal fifth and narrowed on distal fifth; terminal hairs half as long as tube.

Measurements of female holotype in mm.: Body length 3.14; head length 0.326; width back of eyes 0.258; dorsal eye length 0.111; dorsal eye width 0.077; prothorax length 0.215; prothorax width 0.412; tube length 0.344; tube width at base 0.103; tube width at end 0.051; setae on segment 9 and tube approximately 0.232; width of anterior femora 0.086; interocular space 0.086.

Antennal segments:	1	2	3	4	5	6	7	8	Total length
Length	.043	.060	.129	.103	.103	.094	.068	.043	0.643 mm.
Width	.043	.034	.034	.043	.043	.034	.025	.017	

Macropterous male: Color as in female; distinguished from it by a strong spur on the basal segment of foretarsus and because the outer posteroangular seta of abdominal segment 9 is always thornlike and only about half as long as the inner seta. Quite variable as to size and development, the smaller individuals approximating the female and the larger ones attaining more than 4 mm. in length when distended.

Head of allotype relatively longer and narrower than in female, with stronger and more numerous genal thorns, with cheeks straight and barely convergent from eye to basal fifth and, as in female, more strongly narrowed thence to collar-like base. Prothorax exclusive of coxae about 0.362 mm. long and 0.569 mm. wide, with complete, strong median and anteromarginal thickening; with strial pattern forming a more or less distinct whorl at each quadrant of the pronotum. Forefemora five-sixths as wide as head and other parts of forelegs correspondingly developed.

Measurements of male allotype (macropterous) in mm.: Overall length 4.17; head length 0.378; head width 0.258; dorsal eye length 0.137; dorsal eye width 0.086; first postoculars 0.051; second postoculars 0.051; epimerals 0.129; posteromarginals 0.051; anteroangulars 0.043; tube length 0.387; tube width at end 0.060; tube width at base 0.111; posteromarginal seta on ninth abdominal segment 0.215; posteroangular on the same 0.086.

Antennal segments:	1	2	3	4	5	6	7	8	Total length
Length	.060	.060	.146	.129	.120	.103	.077	.043	0.738 mm.

Described from the female holotype and two female paratypes, and the male allotype and 23 male paratypes, all collected by F.A.B. on leaves of a *Psychotria* sp.; Tafuna Forest, Tutuila; December 17, 1951. Named in honor of David Butchart, Director of Agriculture, American Samoa, a friend to whom the author is indebted for many favors. The holotype, allotype, and some paratypes are in the H.S.P.A. collection.

This species is apparently related to the homogeneous group of the genus which Moulton has described from Fiji; but comparison with Moulton's types in the Bishop Museum shows this to be a larger and

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Plate III

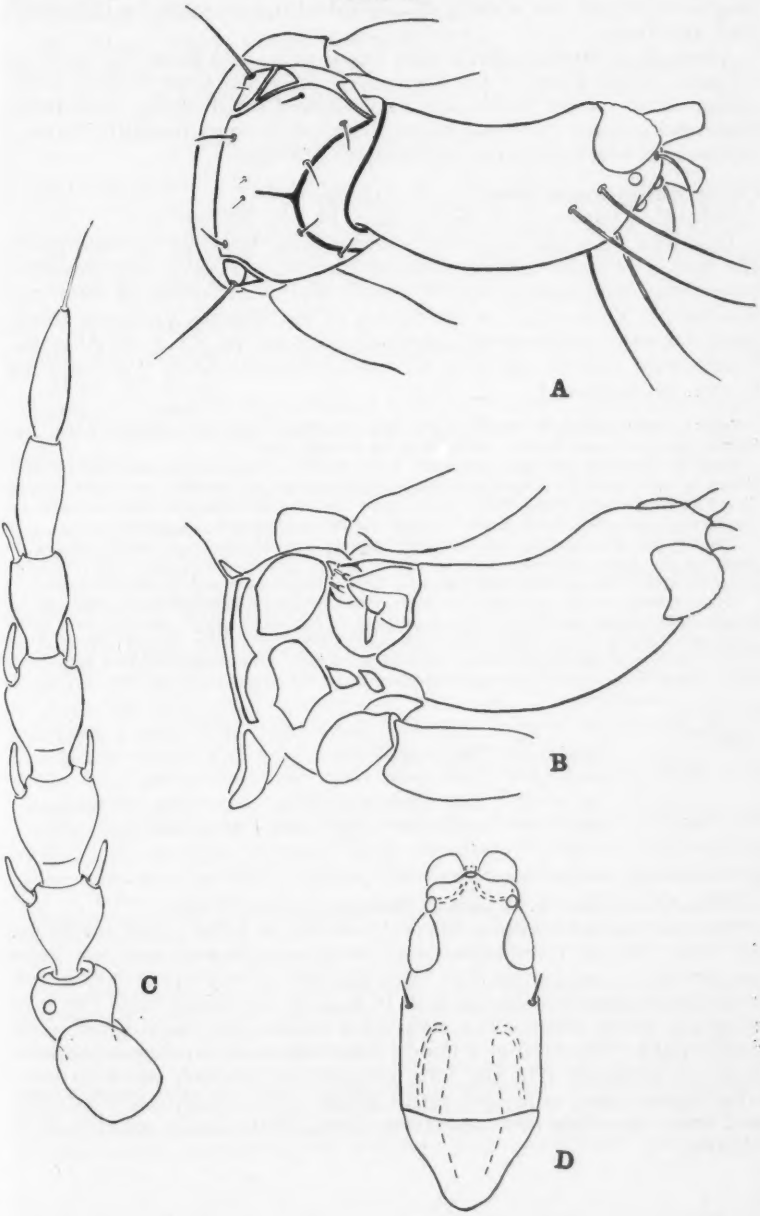
A—*Docessissophothrips magnificus* sp. nov. Dorso-lateral view of head and prothorax of macropterous female.

B—*Docessissophothrips magnificus* sp. nov. Ventro-lateral view of head and prothorax of macropterous female.

C—*Chelaeothrips fuscus* Moulton. Right antenna of macropterous female, without setae.

D—*Chelaeothrips fuscus* Moulton. Dorsal view of head of macropterous female, without microsetae.

Plate III



stronger species than any from Fiji. It is perhaps nearest to *Gynaikothrips magnus* Moulton, but is easily distinguished from *magnus* by its entirely dark antennae.

About 30 or 40 individuals were found at Tafuna loosely grouped on six new, tender leaves of the host plant. They had been feeding on the under surface of the leaves, and these showed small brown, pustule-like scars, and in some cases had begun to roll their edges inwardly, forming cylinders in which the thrips had placed a few eggs.

Chelaeothrips fuscus Moulton (Pl. III, figs. C, D.)

1944—Occ. Papers B. P. Bishop Mus. 17, No. 22:296

Described from Fiji from one apterous male. Study of the holotype in the Bishop Museum collection shows the vertex swollen and produced beyond the eyes, much as in the female, and not as shown in Moulton's illustration. Following is a description of the hitherto unknown female based on two macropterous specimens collected by E.C.Z. at Afiamalu, Upolu, elev. 2,200 ft., on June 25, and on Matafao Trail, Tutuila, 2,000 ft. elev., on August 13.

Color, nearly uniformly brown; tarsi and foretibiae somewhat lighter. Wings uniformly light yellowish brown; with 18 to 24 double cilia.

Head as described for male but with vertex swollen, produced nearly rectangularly ahead of eyes, and bearing the anterior ocellus directed forward and overhanging tip of inter-antennal costa. Hind ocelli large, wide apart, inserted dorso-laterally on the vertex, just above front angles of eyes. Antennae shaped as illustrated.

Thorax and abdomen as described for female. Apical setae on middle and hind tibiae thick, blunt, thornlike; tarsal claws conspicuously developed; both setae on posterior angles of segment nine hair-like, nearly colorless, about as long as tube.

Measurements of two specimens in mm.: Head length on midline 0.387 (.387); cheek length 0.246 (.246); head width at base 0.213 (.221); head width back of eyes 0.200 (.192); eye length 0.106 (.102); eye width 0.057 (.049); prothorax length overall 0.438 (.430); prothorax width including coxae 0.593 (.567); tube length 0.301 (.301); tube width across base 0.164 (.159); tube width at tip 0.061 (.061).

Antennal segments:	1	2	3	4	5	6	7	8	Total
Length	.065	.061	.069	.069	.073	.069	.073	.086	0.565 mm.
Width	.061	.053	.061	.065	.053	.036	.024	.020	
Length	.061	.061	.065	.073	.077	.069	.073	.090	0.569 mm.
Width	.061	.053	.061	.061	.053	.036	.024	.020	

Horistothrips fuscus Moulton

1944—Occ. Papers B. P. Bishop Museum 17, No. 22:293.

One macropterous female collected by E.C.Z. at 1,700 ft. elev. on August 29, Pioa, Tutuila. Comparison with Moulton's apterous holotype leaves no question of its identity. The forewings bear eleven accessory cilia and, under high magnification, seem to be scaly on the distal half. The hind wings are nearly colorless but have a dark median line running out to the distal fourth. The hind and middle legs—which are lacking in the holotype—are relatively thin and long, colored like the body but with somewhat lighter tarsi, with each tarsus armed with a sharp recurved claw, and with the tibiae bearing several long, thin, nearly colorless hairs distally.

Tribe Plectrothripini Priesner

Plectrothrips collaris Bagnall

1909—Trans. Nat. Hist. Soc. Newcastle 3:531.

Described from the island of Nias, Sumatra. One macropterous female collected by E.C.Z. at Tapatapao, Upolu, on June 7, at 1,000 ft. elev.

Tribe Haplothripini Priesner

Haplothrips gowdeyi (Franklin)

1908—*Anthothrips gowdeyi* Franklin—Proc. U. S. Nat. Mus. 33:724.

Cosmopolitan. Six females collected by E.C.Z. on corn ears in Sinaele, Upolu, on July 27, at 1,400 ft. elev.; eight females on the same host at Vailoatai, Tutuila, by F.A.B. in September, 1947.

Karnyothrips flavipes (Jones)

1912—*Anthothrips flavipes* Jones—Tech. Ser. 23, Pt. 1, Bur. Ent. U. S. Dept. Agr. p. 18.

Known in America, West Indies, Hawaii, Sumatra; probably tropicopolitan. One female collected by E.C.Z. on August 11 at the Naval Station, Tutuila.

Tribe Hystricothripini Priesner

Leeuwenia spinosus Moulton (Plate II, fig. F.)

1944—Occ. Papers B. P. Bishop Mus. 17, No. 22:299

Leeuwenia fijiensis Moulton. 1944—L.c., following *L. spinosus* on the same page. **New synonym.**

Comparison of the holotypes, now in the Bishop Museum, leaves no question of the above synonymy. Moulton's illustration of two subequal setae on the posterior prothoracic angles of his *fijiensis* is not accurate. In both holotypes there is only one blunt seta (the epimeral) with a microseta immediately cephalad of it. Other differences indicated in the descriptions are due to poor mounting of the specimens. The real shape of the head in both holotypes is much as described for *fijiensis;* the chaetotaxy of the prothorax as illustrated for *spinosus.*

What appears to be a macropterous male of this species was collected by E.C.Z. at Afiamalu, Upolu, 2,200 ft. elevation, on June 8. A description of the male based on this specimen follows:

Measurements in mm.: Overall length 3.62; head length on sides 0.387; head width at base 0.309; head width across middle of eyes 0.249; prothorax length 0.206; prothorax width 0.447; epimeral seta 0.057; eye length 0.120; eye width 0.086; tube length 0.995; tube width at base 0.129; tube width at end 0.060.

Color yellowish brown, with head, prothorax, sides of pterothorax, and antennal segments 1 and 2 darkest and concolorous. Tarsi and antennal segments 3 to 8 yellowish, with segment 3 lightest and 4 to 8 progressively a little darker.

Head narrower across eyes than at base, with densely thorny cheeks nearly straight, weakly convergent, conspicuously constricted behind eyes. Eyes about half as long as the cheeks and about .7 as wide as long; their inner margins straight and converging posteriorly. Ocelli relatively large; posterior pair just ahead of a line across middle of eyes and nearly contiguous to them; anterior ocellus on tip of produced vertex, overhanging antennal insertion but not attaining tip of inter-antennal costa. Striation

rough, mostly reticular. Antennae shaped as illustrated, inserted on the tangent of both eyes; inter-antennal costa about half as wide as first segment and weakly concave.

Prothorax more than twice as wide as long, weakly concave in front and weakly convex in back; with sides weakly curved and convergent anteriorly; with smoother surface than head; with many microsetae on disk but only one large blunt seta on the epimera. Forefemora incrassate. Foretarsi with a minute curved tooth on inner edge of basal segment. Wings lightly washed with brown; their surface under high magnification apparently roughened with scales and undulating lines which are more conspicuous basally than distally.

Abdomen as described for female; tergite nine with about twenty conspicuous microsetae unevenly distributed over whole surface; tergite eight with a group of about ten on each side, and twelve concentrated in two uneven transverse rows near middle. Tube sparsely setose and about 2.5 as long as head.

Leeuwenia undet. sp.

One macropterous male collected in the same locality as the preceding by E.C.Z. on June 30. Possibly this also is *spinosus*. In most respects it is like that species, but it is smaller than Moulton's specimens or mine, and differs in the shape of the antennae and in the possession of a large tooth on the basal segment of the foretarsus.

Tribe Phlaeothripini Priesner

Phlaeothrips claratibia Moulton

1937—Proc. Haw. Ent. Soc. 9, (3):414

1947—Pan-Pac. Entomologist 23, (4):175

Known from Hawaii and New Guinea. E.C.Z. collected one female at Afiamalu, Upolu, 2,100 ft. elev., on July 13; one female at Tapatapao, Upolu, 800 ft. elev., on July 20; and six females and five males at Falefa Falls, Upolu, on June 3.

Tribe Docessissophothripini Priesner

Docessissophothrips magnificus new species. (Pl. III, figs. A, B.)

Macropterous female: Length fully extended 7 mm. Color by transmitted light: head and abdominal segments 3-10 dark brown, nearly black; prothorax, pterothorax, abdominal segments 1-3, and coxae lighter brown; legs yellowish brown. Antennal segments 1 and 6-8 concolorous with prothorax; 2 yellowish medianly and distally; 3 yellow tinged with brown on distal third; 4 yellow medianly, tinged brown basally and distally; 5 like 6-8 but lighter on basal third. Forewings washed with brown, fading to nearly clear in distal and basal sixths. Hind wings fading on distal sixth; with a clear band between anterior margin and midline, which are darker than rest of wing. Marginal cilia, including about 50 accessories, concolorous with wing. Subbasal setae, like all body setae, clear or nearly so; evenly spaced and increasing in size to the distal one which is 0.068 mm. long.

Head about 2.5 times as long as wide; strongly convex above and concave below; with a strong basal carina dorsally, the vertex flattened between the eyes, the front ocellus forwardly directed, the hind ocelli nearly contiguous with the eyes and just cephalad of a line through their middle. Eyes finely faceted; in dorsal view nearly oval, protruding, occupying about one-sixth of head length; in lateral view with an angular caudo-ventral extension. Anteocellar setae long and conspicuous, well ahead of anterior ocellus and near eye margin. Postocellars near to ocelli and minute. Anterior postoculars inward of inner eye margin and slightly back of their hind margin; second postoculars about 0.103 mm. caudad of the first and on the same longitudinal line. Antennae about as long as head; inserted ventrally and with narrow inter-antennal costa just visible from above in dorsal view; with pale, inconspicuous hairs and short, acute sense cones no

longer than one-quarter the length of the corresponding segments. Mouth cone broadly rounded; reaching to about middle of prosternum.

Pronotum deeply concave and strongly carinate on front margin; with weak, incomplete median apodeme. Epimera separated by wide depression from pronotum, nearly tubercular and bearing the long, thin, pale epimeral seta at the summit. Other pronotal setae small and inconspicuous.

Legs rather long and thin, with laterally prominent coxae. The fore femora incrassate but not as thick as the head. Pterothorax nearly quadrate, only slightly narrowed caudally. Abdomen of almost equal width to segment 8, which is angularly constricted to the much narrower 9. Posteroangular setae colorless and relatively thin but as long or longer than corresponding segments; the longest on segment 9. Tube .7 as long as head; gradually narrowed from base to near the end, where it is suddenly roundly constricted to the weak terminal hairs, of which the longer are 0.164 mm. long.

Measurements of female holotype in mm.: Head length about 1.02; head thickness dorso-ventrally about 0.425; anterocellars 0.17; postoculars 0.306; epimerals 0.17; pronotum length 0.17; prothorax width without coxae 0.595; pterothorax width in front 0.816; pterothorax length on side 0.850; tube length 0.714; tube width at base 0.204; tube width at end 0.085.

Antennal segments:	1	2	3	4	5	6	7	8	Total
Length	.102	.136	.238	.136	.136	.119	.085	.085	1.037 mm.
Width	.085	.068	.059	.068	.059	.051	.042	.034	

Macropterous male: Color as in female; size smaller, only 6 mm. long. Head smaller in relation to body and less strongly arched than in male; prothorax longer. Abdomen reduced gradually from second segment. Basal segment of foretarus produced inwardly into a stout spur.

Measurements of male allotype in mm.: Head length 0.788; head width across cheeks 0.323; tube length 0.595; tube width at base 0.153; tube width at end 0.085; width of forefemora 0.255; pronotum length 0.258; prothorax width including coxae 0.680; pterothorax width 0.799; pterothorax length 0.595.

Described from the female holotype collected at Afiamalu, Upolu (elev. 2,200 ft.) on July 10, 1940, by E. C. Z., and the male allotype collected in the same locality at 2,100 ft. on June 13. Both of these are in the Bishop Museum.

Judging from descriptions this species seems to resemble *D. adiaphorus* Karny in color and shape. But it differs from *adiaphorus* in its much greater size; in the possession of long anteocellars; in the relative lengths of the setae on the prothorax and the subbasals on the forewings; in the size and shape of the antennal sense cones; and in having about 50 double hairs on the forewings instead of 17.

Subfamily Megathripinae Priesner
Tribe Compsothripini Priesner

Dichaetothrips setidens (Moulton)

1928—*Mesothrips setidens* Moulton—Proc. Haw. Ent. Soc. 7, (1):129

1944—*Dichaetothrips setidens* (Moulton)—Occ. Papers B. P. Bishop Museum 17, No. 22:308

Known in Hawaii, Fiji, Tuamotus, Mangareva. E.C.Z. collected one female in Tapatapao, Upolu, on July 13, at 1,000 ft. elev., and one female in Swain's Island on August 20; and F.A.B. one female at Vailoatai, Tutuila, in 1947.

Rhaebothrips major Bagnall

1928—Insects of Samoa. Part 7, fasc. 2:75

1944—Moulton (nec Bagnall) Occ. Papers B. P. Bishop Museum 17, No. 22:303

1945—Bianchi (nec Bagnall) Proc. Haw. Ent. Soc. 12 (2):280

E.C.Z. collected sixteen males and two females at Afiamalu, Upolu, 2,100-2,200 ft. elev., on various dates between June 13 and July 10; and two males and three females at Fagatogo, Tutuila, 700 ft. elev., on various dates between August 8 and August 28.

These specimens are all remarkably alike in major and minor features, and agree with Bagnall's description. Unfortunately, they were not available to us in 1944 and 1945, or their study would have prevented Moulton and, following him, the present author, from misinterpreting Bagnall's description. Now, careful comparison of them with Moulton's material from Fiji—borrowed from the California Academy of Sciences—and with numerous collections from Hawaii leaves no doubt that the Samoan *major* is a different species. The identity of the Fijian and the Hawaiian species remains to be clarified.

New Microlepidoptera from Fiji

By J. D. BRADLEY

DEPARTMENT OF ENTOMOLOGY, BRITISH MUSEUM (NATURAL HISTORY)

Of the following five new species, four are represented by material received for determination from B. A. O'Connor, Government entomologist in Fiji, and one was confused with *Argyroploce aprobola* (Meyrick) in the series of that species in the British Museum (Natural History).

The Commonwealth Institute of Entomology has arranged the presentation of the types and certain of the paratypes of the four species described from material collected by Mr. B. A. O'Connor to the British Museum, and of paratypes to the Experiment Station, H.S.P.A., in Honolulu, Hawaii. The types and paratypes of *anaprobola* n. sp. are in the British Museum.

OLETHREUTIDAE

Argyroploce anaprobola, new species (Figs. 5 and 8)

Expanse of forewings: ♂, 10 to 13 mm.; ♀, 12 to 15 mm.

Labial palpus fuscous, head ochreous white heavily suffused with fuscous brown on vertex and face, thorax ochreous white irrorated with fuscous, tegula ochreous white, fuscous at extreme base and sometimes tipped with pale leaden scales at apex. Antenna pale ochreous, scape brownish.

Forewing ochreous white strigulated and mostly suffused with pale ochreous and fuscous brown, costa shortly strigulated with black, inner edges of strigulations outlined with white, an irregular poorly defined fascia from middle of costa to little beyond middle of dorsum, narrow at costa widening obliquely to near middle of wing, this part fuscous black and with inner edges weakly outlined with ochreous, remainder of fascia indistinct, narrowing toward dorsum, fuscous brown mixed and suffused with pale ochreous; tornal area whitish, broadly edged with blackish apically; a smaller whitish patch before fascia on dorsum, sometimes partly obscured by a suffusion of pale ochreous, three or four fairly conspicuous black dashes arranged irregularly one above the other in apical half of whitish tornal area; a short white line on termen a little beneath apex with two or three minute black dots in outer margin and a few blackish scales beyond these in cilia; a trace of glossy grayish iridescence in distal margin of whitish tornal area and in parts of the forewing which have light coloration, and as a distinct line edged with ochreous below the strigulations in the apical half of the costa. Cilia pale ochreous except at tornus where they are white.

Hindwing ochreous gray; cilia sordid white with an ochreous gray subbasal line.

Abdomen ochreous gray dorsally; pale ochreous ventrally; a small pale ochreous anal tuft.

Foreleg pale ochreous heavily suffused with fuscous brown, tarsus blackish fuscous with two sharply defined rings situated close together at the middle; middleleg ochreous white, tibia thickened by scales, suffused with fuscous exteriorly, tarsus blackish fuscous, three evenly spaced sharply defined white rings; hindleg pale ochreous, tarsus slightly infuscated, three ill-defined whitish rings.

In the female the coloration and markings of the forewing are much the same as in the male except for a heavy ochreous suffusion obscuring or partly obscuring the whitish dorsal patch basad to the transverse fascia; in some examples the whole forewing has a reddish ochreous appearance and the white tornal area is suffused with

slightly glossy pale leaden scales; sometimes the black dashes are increased in number to as many as eight or nine and extend nearly to apex, those nearest the apex are slightly longer than those in the vicinity of the tornus.

Male genitalia: Fig. 5. Female genitalia: Fig. 8.

Holotype ♂: Fiji, Viti Levu, Lautoka, 7. xii. 1921, W. Greenwood, ex *Glochidion* sp. Genitalia slide B. M. 2520.

Allotype ♀: same data as holotype, but dated 11. xii. 1921. Genitalia slide B. M. 2478.

Paratypes 4♂, 4♀: same data as holotype, but various dates in xii. 1921. Genitalia slides B. M. 2508 and B. M. 2958.

This species is superficially very similar to *Argyroploce aprobola* (Meyrick), but is smaller. It is difficult to give differences by which to separate them because of variability. The whitish markings at the tornus and on the dorsum of the forewing of *anaprobola* are whiter and more pronounced when present than in *aprobola;* in both sexes of *aprobola* there is usually a prominent patch of black scales on the dorsum in the transverse fascia. The male genitalia of these two species are quite distinct, and *anaprobola* can be distinguished by the apical half (cucullus) of the valva being more narrow than the basal half; while in *aprobola* the reverse is the case. The female genitalia are not quite so easily separated but nevertheless show good differences in the ostium. The ostium opening in *aprobola* is nearly half as long again as in *anaprobola* and the sclerotized anterior margin is much narrower; the posterior lateral corners are tapered and straight in *anaprobola,* but in *aprobola* are thickened and curve outwards; the excavation of the posterior margin of the seventh sternite is deeper in *aprobola* as a result of the elongated ostium opening.

GELECHIIDAE

Myconita lipara, new species (Fig. 9)

Expanse of forewings: 14 mm.

Labial palpus pale yellow ochre except apical half of third segment which is fuscous. Head and thorax pale yellow ochre, tegula fuscous. Antenna blackish fuscous, basal half in male considerably thickened.

Forewing with costal two-thirds fuscous in general appearance and dorsal third pale ochre; two small yellow ochre spots ringed with ferruginous arranged longitudinally in middle of forewing, a blackish dash edged with ferruginous between them and another after the distal-most spot; an irregular suffusion of yellow ochre with an admixture of ferruginous diagonally from these two spots to near apex; a pale yellow ochre spot on costa a little before apex, arising from this costal spot is a transverse yellow ochre line broadly edged with blackish outwardly; the pale yellow ochre dorsal part of the wing is edged inwardly with ferruginous and lightly suffused with ferruginous at tornus; a yellow ochre streak overlaid with ferruginous from near base along vein 12 and ending just before costa. Cilia ochreous yellow around tornus, fuscous along termen to apex and with five minute ochreous spots evenly spaced along basal line.

Hindwing shining gray, cilia gray.

Abdomen grayish, suffused with ochreous ventrally.

Foreleg grayish fuscous, basal four tarsal segments pale yellow ochre, apical tarsal segment blackish fuscous; middleleg with tibia and tarsus fuscous, tibia with apex and spurs ochreous yellow, tarsus with broad yellow band medially; hindleg pale ochreous suffused exteriorly with fuscous.

Male genitalia: not seen. Female genitalia: Fig. 9 (paratype, genitalia slide B.M. 2892).

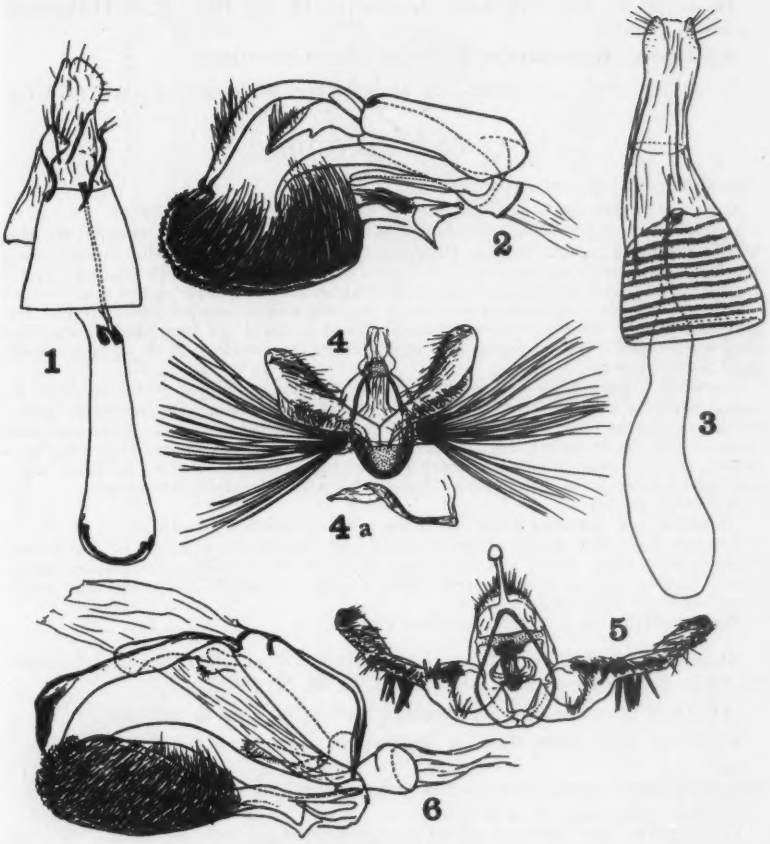


Fig. 1 **Bedellia ipomoeae,** new species
Female genitalia, ventral view.

Fig. 2 **Pyroderces similis,** new species
Male genitalia, lateral view.

Fig. 3 **Pyroderces similis,** new species
Female genitalia, ventral view.

Fig. 4 **Bedellia ipomoeae,** new species
Male genitalia, ventral view.

Fig. 4a **Bedellia ipomoeae,** aedeagus.

Fig. 5 **Argyroploce anaprobola,** new species
Male genitalia, ventral view.

Fig. 6 **Stagmatophora cyma,** new species
Male genitalia, lateral view.

Holotype ♀: Fiji, Viti Levu, Koronivia, 19. xii. 1951, B. A. O'Connor, ex sweet potato.

Allotype ♂: same data as holotype, abdomen missing.

Paratypes: 3 ♀, 1 ♂, same data as holotype, abdomen of male missing.

COSMOPTERYGIDAE

Pyroderces similis, new species (Figs. 2 and 3)

Expanse of forewings: 7 to 8 mm.

Labial palpus light reddish brown, whitish toward base interiorly, terminal segment with a fuscous subapical annulus. Head, thorax and tegula light reddish brown, lower face and tongue whitish. Antenna with basal two-thirds wholly whitish ventrally, apical half of each segment whitish and basal half blackish brown dorsally; apical third fuscous with scales slightly roughened, penultimate segment ringed with silvery white apically, preceded by two wholly fuscous segments, basad to these are two pairs of segments ringed with silvery white apically and separated by two wholly fuscous segments; scape light reddish brown.

Forewing light reddish brown, a transverse outwardly oblique white fascia at ¼, edged inwardly with raised black scales, an ill-defined whitish mark in middle with a small patch of jet black scales beneath and nearly on dorsum; a whitish transverse dash from costa a little before apex extending almost to termen thence continuing as a poorly defined inwardly oblique streak terminating at or near tornus; a whitish elliptical spot above tornus. Cilia grayish, a slight blackish infuscation below apex.

Hindwing grayish.

Abdomen pale ochreous dorsally, shining whitish ochreous ventrally.

Foreleg and middleleg pale ochreous ringed with fuscous; hindleg light reddish brown, basal third of tibia white, a minute speck of raised black scales outwardly at base, a broad fuscous ring in middle of each spur, a comb of fine pale ochreous hair above, tarsal segments ringed with fuscous.

Male genitalia: Fig. 2. Female genitalia: Fig. 3.

Holotype ♂: Fiji, Viti Levu, Lami, Suva, 28. xi. 1951, B. A. O'Connor, ex male flower *Pandanus*. Genitalia slide B. M. 2902.

Allotype ♀: same data as holotype, genitalia slide B. M. 2890.

Paratype 1 ♂: same data as holotype.

Stagmatophora cyma, new species (Figs. 6 and 7)

Expanse of forewings: 15 to 18 mm.

Labial palpus pale ochreous, second segment with three brownish annuli, third segment with a broad fuscous annulus medially, a subapical annulus and a slight infuscation at base. Head whitish ochreous, thorax pale ochreous with a broad dark brown strip at each side, tegula pale ochreous flecked with brown. Antenna and scape pale ochreous slightly irrorated with brown; a small fuscous mark at apex of scape anteriorly and another much smaller mark adjoining it at base of antenna.

Forewing whitish ochreous with pale ochreous and brownish wave-like markings; basal third brown, outer edge outwardly oblique and outlined with black, a whitish ochreous streak from base below costa and parallel to it, ending midway and followed by a small black dash; brownish markings above and below this streak before middle; a brown marking from about middle of dorsum to near tornus, inner edge evenly curved reaching nearly to middle, curving upward before reaching dorsum and continuing as a brown undulating line to apex; apex blackish fuscous, divided into three by two wedge-like silvery marks, one going to costa and one to termen; an ovate brown marking on costa at ¾. Cilia grayish at tornus and termen, pale ochreous mixed with blackish scales at apex.

Hindwing ochreous gray, cilia grayish tinged ochreous at base.

Abdomen pale ochreous suffused with brown.

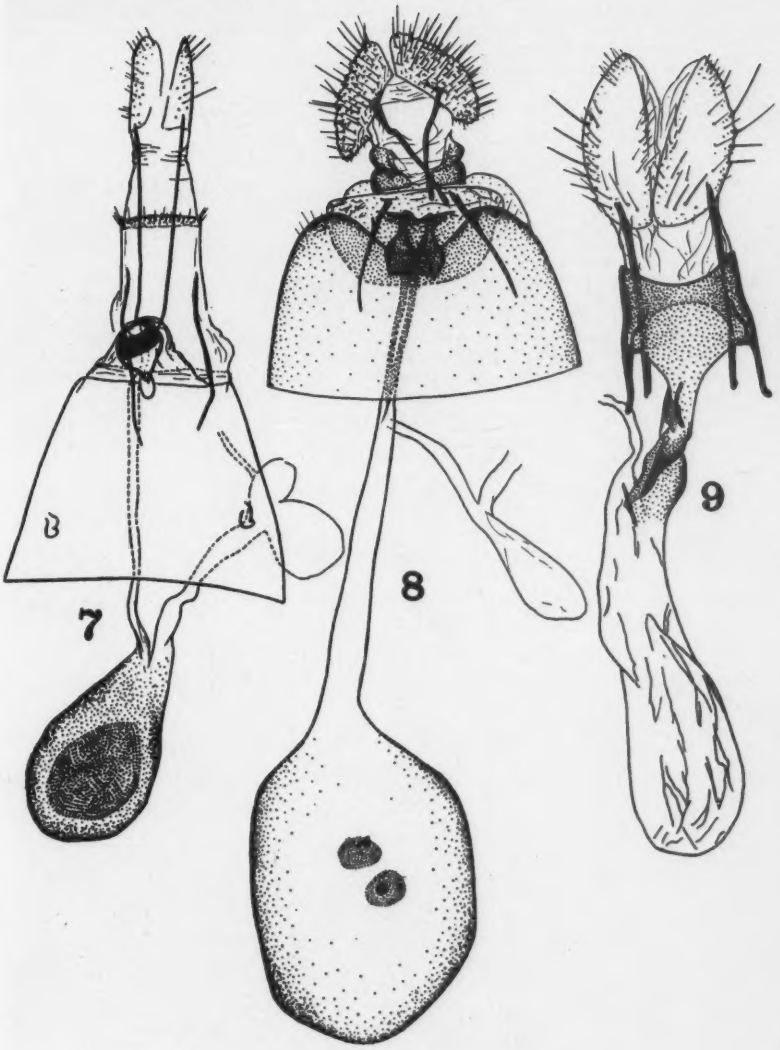


Fig. 7 **Stagmatophora cyma,** new species
Female genitalia, ventral view.

Fig. 8 **Argyroploce anaprobola,** new species
Female genitalia, ventral view.

Fig. 9 **Myconita lipara,** new species
Female genitalia, ventral view.

Foreleg fuscous, tibia ringed with pale ochreous at apex, tarsus with broad pale ochreous annulus medially; middleleg and hindleg pale ochreous with tarsi and spurs striped obliquely with fuscous.

Male genitalia: Fig. 6. Female genitalia: Fig. 7.

Holotype ♂: Fiji, Viti Levu, Lami, Suva, 28. xi. 1951, B. A. O'Connor, ex male flower *Pandanus*.

Allotype ♀: same data, genitalia slide B. M. 2891.

Paratypes 8 ♂ ♀: same data as holotype, genitalia slide B. M. 2881.

LYONETIIDAE

Bedellia ipomoeae, new species (Figs. 1, 4 and 4a)

Expanse of forewings: 8 to 9 mm.

Labial palpus, head and thorax pale ochreous, head rough scaled, vertex and crown mixed with brown; thorax lightly irrorated with brown. Antenna and scape pale ochreous, antenna with grayish fuscous annulations, scape lightly irrorated with dark brown.

Forewing pale ochreous lightly irrorated with dark brown, this giving the wing a peppered appearance. Cilia pale ochreous.

Hindwing gray, cilia pale ochreous.

Abdomen grayish dorsally, whitish ochreous irrorated with dark brown ventrally.

Legs whitish ochreous, foreleg strongly suffused with fuscous brown; middleleg and hindleg with dark brown irrorations.

Male genitalia: Figs. 4 and 4a. Female genitalia: Fig. 1.

Holotype ♂: Fiji, Koronivia, 19. xii. 1951, B. A. O'Connor, ex sweet potato. Genitalia slide B. M. 2904.

Allotype ♀: same data as holotype, genitalia slide B. M. 2893.

Paratypes: 12 ♂ ♀ same data as holotype, genitalia slide B. M. 2901.

A Premating Period in Certain Species of the Genus Opius (Hymenoptera: Braconidae)

By KENNETH S. HAGEN

DEPARTMENT OF BIOLOGICAL CONTROL, UNIVERSITY OF CALIFORNIA

The majority of species belonging to the genus *Opius* that parasitize various tephritid species in the Hawaiian Islands will mate immediately after emergence. However, in two *Opius* species a distinct period of time must elapse after emergence before the males will copulate. This period is designated by the author as the premating period.

It is well known that the males of all the species discussed herein begin emerging before the females. This differential in emergence may at times be two days in length. However, with the exception of the two species having the premating period, when the newly emerged males are exposed to females of a different brood they will copulate immediately.

The species *Opius humilis* Silvestri, *O. fullawayi* (Silvestri), and *O. tryoni* Cameron, parasites of *Ceratitis capitata* (Wiedemann), mate immediately after emergence (Back and Pemberton, 1918; Pemberton and Willard, 1918). The melon fly parasite, *O. fletcheri* Silvestri, shows the same behavior (Willard, 1920). Another parasite of *Dacus cucurbitae* Coquillett, *O. watersi* Fullaway, and the parasites of *D. dorsalis* Hendel, *O. longicaudatus* (Ashmead) and *O. formosanus* Fullaway, were observed to copulate just after emergence.

The two species in which the males apparently require a prolonged period after emergence before they will copulate are *O. oophilus* Fullaway and *O. vandenboschi* Fullaway. These species are parasites of the oriental fruit fly, *D. dorsalis,* and differ from the above-mentioned species by ovipositing in the host eggs (van den Bosch, *et al.,* 1951) or in the first instar larvae (Bess, *et al.,* 1950), respectively, rather than in the large larvae.

A study of the adult male internal reproductive systems of these two species revealed different degrees of spermatozoan migration through the genital ducts dependent upon age. In newly emerged males the only free, active spermatozoa were confined to the testes near the bases of the vasa deferentia. After five or six days at a mean temperature of about 80°F., dissections showed the spermatozoa to have reached the vesicula seminalis. It is not until the spermatozoa have reached this point that the males show any observable sexual behavior.

If both sexes of either *O. oophilus* or *O. vandenboschi* are allowed to remain together for five or six days after emergence they still may not copulate. However, if the sexes are kept separate for five or six days and then mixed, a mating behavior occurs immediately. The absence of mating in the former case where the males were sexually mature is ap-

parently associated with a lack of an attractant gradient between sexes. An obliteration of gradients between sexes is perhaps the result of air saturation of sexual odors. This hypothesis is supported by the fact that when carbon dioxide or even fresh air is blown through the cage, a mating reaction occurs (flipping of wings, Whiting, 1932) and mating is stimulated soon after the cessation of the flow of the CO_2 or air. It was found that the males of all the *Opius* species studied have internal glands which originate in the pygidium. A faint oblique line near the lateral, posterior angles of the pygidium can be seen externally. These glands apparently differ interspecifically. An odor evidently from these "scent glands" is perceptible to humans.

LITERATURE CITED

Back, E. A. and **C. E. Pemberton.**

1918. The Mediterranean fruit fly in Hawaii. U. S. Dept. Agr. Bull. No. 536 (Prof. Paper). 118 pp.

Bess, H. A., R. van den Bosch, and **F. Haramoto.**

1950. Progress and status of two recently introduced parasites of the oriental fruit fly, *Dacus dorsalis* Hendel, in Hawaii. Proc. Haw. Ent. Soc. 14 (1) :29-33.

Pemberton, C. E. and **H. F. Willard.**

1918. A contribution to the biology of fruit fly parasites in Hawaii. Jour. Agr. Res. 15 (18) :419-465.

van den Bosch, R. and **F. H. Haramoto.**

1951. *Opius oophilus* Fullaway, an egg-larval parasite of the oriental fruit fly discovered in Hawaii. Proc. Haw. Ent. Soc. 14 (2) :251-255.

Whiting, P. W.

1932. Reproductive reactions of sex mosaics of a parasitic wasp, *Habrobracon juglandis*. Jour. Comp. Psych. 14:345-363.

Willard, H. F.

1920. *Opius fletcheri* as a parasite of the melon fly in Hawaii. Jour. Agr. Res. 20 (6) :423-438.

Preliminary Studies in Hawaiian Dolichopodidae (Diptera)[1] Part I. New Species of Campsicnemus Haliday

By MARIAN S. ADACHI

COLLEGE OF AGRICULTURE, UNIVERSITY OF HAWAII
AGRICULTURAL EXPERIMENT STATION

The new species described in this study belong in the complex of *Campsicnemus* which have short basitarsi or cleft tibiae on the mesothoracic legs of the males. These species all run within couplets 25 to 28 of Parent's key to the Hawaiian *Campsicnemus* ("PROCEEDINGS,"[2] 10:236-240, 1939). This genus has been commonly but incorrectly attributed to Walker in the dolichopodid literature: the original reference is *Campsicnemus* Haliday, in Walker's INSECTA BRITANNICA, Diptera, I:187, 1851. It has also been consistently treated as a masculine word although the name is derived from the Greek Καμψος – bent, or crooked, + Κνημη – tibia, the latter being a feminine noun. The material studied was collected in connection with Dr. D. E. Hardy's project on the Diptera of Hawaii.[3] As part of this project the entire family will be revised in the near future.

Campsicnemus arcuata new species (Figs. 2a-d)

This species runs to *C. vafellus* Parent in couplet 28 in Parent's key (loc. cit.). It differs from *vafellus* in the shape of the male antennae (cf. figs. 1a and 2a), in the chaetotaxy of the legs (cf. figs. 1b and 2b) and by the darker coloration of the mesonotum. The antennae of the males in *vafellus* are narrowed at the apex, whereas the antennae of *arcuata* are rounded in both sexes. Like *vafellus*, the middle tibia is fusiform and cleft at the apex; both have the middle basitarsus very short and terminating in a rather long spine.

Male. The junction of the compound eyes equal in length to the five facets of the eyes and also equal to lower portion of face. Visible parts of face and front dark brown to black, with a bluish metallic luster on the front. The ocellar triangle is large; half as long as front and almost one-third width of vertex. There are two strong ocellar bristles. Antennae yellow with black, pubescent aristae. Second segment has a crown of short, black bristles at the apex. Third segment twice as long as second segment and covered with fine pubescence (fig. 2a).

Mesonotum predominantly brown, paler on extreme lateral margins. Humeri and scutellum yellow-brown; each has a pair of bristles. The outer humeral weakly developed. There are four pairs of dorsocentral, one pair of posthumeral, one pair of presutural, two pairs of notopleural, two pairs of supraalar (the anterior pair weaker than the posterior), and one pair of postalar bristles. Acrosticals uniserial, extending over half the length of mesonotum. The upper portion of the pleura brown and the lower part yellow. One bristle present on propleuron. Halteres yellow.

[1] Published with the approval of the Director of the Hawaii Agricultural Experiment Station as Technical Paper No. 276.

[2] "PROCEEDINGS" refers to Proceedings of the Hawaiian Entomological Society.

[3] This project is being supported by the National Science Foundation.

Wings hyaline with a conspicuous costal bristle near base. Apical half of subcosta fused with R_{1+2}. The subcosta is fused with R_{1+2} on the apical half of the wing. Veins R_2, R_{4+5}, and M_{1+2} almost parallel on apical half of wing. Distal portion of vein $M_{3+4} + Cu_1$ more than twice length of the m crossvein.

Legs yellow except for a brown spot on each middle coxa and a slight browning at the apex of each hind femur. *Prothoracic legs:* Tibia about two-thirds as long as femur. Basitarsus three-fourths length of tibia. Second and third tarsal segments equal in length and equal to one-third of basitarsus. *Mesothoracic legs:* Coxa brown on the outer surface. Femur much shorter than tibia and armed with four long and one short bristle at base on ventral surface. Tibia long, slightly twisted and flattened dorsoventrally (fig. 2b); dorsum of tibia very bristly and cleft at apex. There is a strong bristle just above the cleft on the postero-dorsal margin, and a patch of very short, stout bristles to the side of it on the anterior dorsum. On ventral surface, apical half is covered with setae and has one subapical bristle; basal half lined with setae on lateral margins. Basitarsus very short and bears a black spine at apex; it is two-thirds length of following segment and one-half of third tarsal segment (fig. 2c). *Metathoracic legs:* Coxa with one bristle on anterior corner. Femur possesses one preapical bristle on anterior surface; venter of femur lined with bristles at base and has one long bristle near apex. Tibia long and slender, much longer than femur and has the following bristles: four anterior dorsal, four posterior dorsal, and three ventral. Basitarsus one-fourth as long as tibia; second tarsal segment slightly longer than first (fig. 2d).

Abdomen dark brown with six visible segments.

Length: body, 2.0 mm.; wings, 2.7 mm.

Female. The females resemble the males very closely except for the chaetotaxy of the legs. *Prothoracic legs:* On dorsal surface of tibia, there are two bristles, one median and one apical. Basitarsus one-third as long as tibia and twice as long as second tarsal segment. *Mesothoracic legs:* Femur has a strong preapical bristle on anterior surface. Tibia long and slender with four anterior dorsal, two posterior dorsal, and three ventral bristles. Basitarsus one-third length of tibia and twice as long as following segment. *Metathoracic legs:* There is one coxal bristle. The femur has a row of setae on venter and one preapical bristle. Tibia slightly longer than femur; it has four anterior dorsal, four posterior dorsal, and three ventral bristles. First two tarsal segments subequal in length and about one-fourth as long as hind tibia.

Abdomen dark brown with five visible segments.

Holotype male and allotype female, Puu Kolekole, Molokai, 4,000 ft. elevation (21° 6′ N, 156° 54′ W), July, 1952, (M. Tamashiro); 77 paratypes, 41 males and 36 females, same data as type, (D. E. Hardy and M. Tamashiro).

The type, allotype, and a series of paratypes are being deposited in the United States National Museum. Paratypes are being placed in the following collections: B. P. Bishop Museum, Hawaiian Sugar Planters' Association, British Museum (Natural History), and the University of Hawaii.

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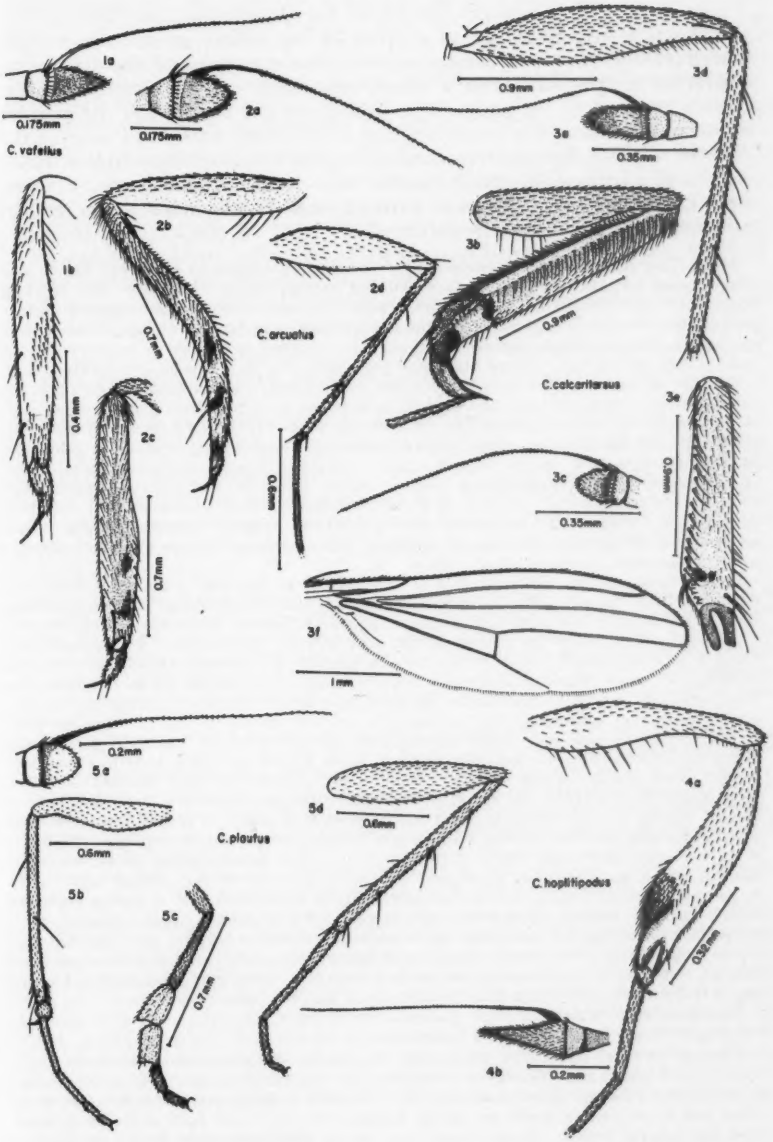
1. **Campsicnemus vafellus** Parent. **a.** antenna of male; **b.** middle tibia and basitarsus of male, dorsal view.
2. **Campsicnemus arcuata** n. sp. Male. **a.** antenna; **b.** middle femur, tibia and basitarsus, posterior dorsolateral view; **c.** middle tibia and basitarsus, dorsal view; **d.** hind femur, tibia, and tarsus.
3. **Campsicnemus calcaritarsus** n. sp. **a.** antenna of male; **b.** middle femur, tibia and tarsus of male, anterodorsal view; **c.** antenna of female; **d.** hind femur and tibia of male; **e.** middle tibia of male, dorsal view; **f.** wing of male.
4. **Campsicnemus hoplitipodus** n. sp. Male. **a.** middle femur, tibia and tarsus, anterodorsal view; **b.** antenna.
5. **Campsicnemus plautina** n. sp. Male. **a.** antenna; **b.** mesothoracic leg, posterodorsal view; **c.** front tarsal segments, lateral view; **d.** hind leg, lateral view.


1a
0.175mm
2a
0.175mm
C. vafellus
3d
0.9mm
3e
0.35mm
1b
0.4mm
2b
0.7mm
2c
0.7mm
C. arcuatus
2d
0.8mm
3b
0.9mm
C. calcaritarsus
3e
0.8mm
3c
0.35mm
3f
1mm
5a
0.2mm
0.6mm
5b
C. plautus
5c
0.7mm
5d
0.6mm
C. hoplitipodus
4a
0.8mm
4b
0.2mm

Campsicnemus calcaritarsus new species (Figs. 3a-f)

This is one of the larger species of *Campsicnemus*. In Parent's key (loc. cit.), it will go as far as couplet 22 but differs in that the middle basitarsus does not have a membranous lobe or a spine at the apex. The basitarsus is spur-like with a sclerotized ridge on the dorsum and is acutely pointed at the apex. The pattern of the bristles on the middle tibiae and the antennae resembles that of *C. membranilobus* Parent. Like *membranilobus*, the anterior dorsal margin of the middle tibiae is lined with a row of bristles which extend to a patch of short, stout bristles. The tibiae are more densely bristled and much more thickened in *calcaritarsus* than in *membranilobus*.

Male. The junction of the compound eyes equal in length to seven eye facets, and about equal to lower portion of face. Ocellar triangle large and more than one-half length of front. Ocellar bristles well-developed. Antennae yellow; third segment slightly longer than two basal segments. Second antennal segment bears a crown of black setae on apical margin; third segment elongate and rounded at apex. It is covered with pale yellow pubescence. Arista black and pubescent (fig. 3a). Postocular bristles black.

Thorax ochraceous. Mesonotum has a fine longitudinal median strip and two broader lateral stripes which fuse on hind part of mesonotum to form a broad prescutellar spot. Alined with the lateral stripes are four dorsocentral bristles, the posterior pair displaced to the sides, and a single row of acrosticals extending a little more than half length of mesonotum on the median stripe. Each humerus has a pair of bristles, the inner one more strongly developed than the outer. There are two pairs of posthumeral, two pairs of notopleural, one pair of presutural, two pairs of supraalars, and one pair of postalar bristles. The scutellum has a pair of marginal bristles. Pleura yellow except for a brown spot covering pteropleura. One propleural bristle is present directly above front coxa. Halteres clear yellow.

A long conspicuous bristle present at base of costa. Subcosta fused with vein R_{1+2} on apical half. Veins R_2, R_{4+5} and M_{1+2} are nearly parallel in apical half of the wing. The m crossvein is less than half length of apical portion of veins $M_{3+4} + Cu_1$ (fig. 3f).

Legs all yellow except for a large brown spot on each middle coxa. *Prothoracic legs:* Coxa is setaceous on front with fine bristles around the margin. Tibia three-fourths as long as femur. Basitarsus slightly shorter than tibia, second tarsal segment less than one-half length of basitarsus. *Mesothoracic legs:* Coxa has a large brown spot and a bristle on upper anterior corner. On ventral surface of femur, there are four to six bristles at base and several shorter setae on apical third (fig. 3b). Femur also has a preapical bristle on posterior surface. Tibia greatly enlarged and thickened and longer than femur. Apex of tibia deeply cleft. There are two patches of short, stout spines located near the apical fifth of the tibia just above the cleft (fig. 3e). A row of bristles extends along anterior dorsal margin to patch of spines and terminates near three long spinous bristles which curve around to the venter (fig. 3b). Posterior dorsal margin, with, near apex of tibia, a row of five bristles along posterior dorsal margin and a more strongly developed bristle on posterior dorsal surface above cleft. A preapical dorsal bristle anterior to inner end of tibial cleft and a strong preapical bristle on the venter. Basitarsus spur-shaped with a dorsal bristle located on a sclerotized ridge. Second and third tarsal segments equal in length. *Metathoracic legs:* Coxa with a bristle on anterior corner and femur with a preapical bristle on anterior surface. Tibia with four anterior dorsal, five posterior dorsal and four ventral bristles; (fig. 3d) the basitarsus is less than one-third the length of the tibia.

Abdomen dark brown to black with six visible segments.

Length: body, 3 mm.; wings, 3.7 mm.

Female. General coloration, wings and chaetotaxy of thorax the same as in males. Face yellow-white and narrowed in the center. Third antennal segment short and rounded; not elongate as in males (fig. 3c). Females possess normal middle legs. Front tibia has four bristles, three on dorsal surface, two on basal half and one at apex, and one ventral bristle. *Mesothoracic legs:* Femur has a preapical bristle on anterior and posterior sides. Tibia slightly longer than femur and armed with four anterior

dorsal, two posterior dorsal, and four ventral bristles. Two of the ventral bristles are located at the apex, one almost twice as long as the other. Basitarsus one-fourth length of tibia; second tarsal segment slightly longer than first. *Metathoracic legs:* Coxa has one bristle on anterior corner, and femur has one preapical bristle, the tibia has four anterior dorsal, five posterior dorsal, and four ventral bristles as in males. Posterior basitarsus approximately one-fourth as long as tibia and second tarsal segment about one-third as long.

Abdomen dark brown to black with five visible segments.

Holotype male and allotype female, Manawainui Valley, Molokai, 2,000 ft. elevation (21° 8′ N, 156° 59′ W), July, 1952, (D. E. Hardy); 15 paratypes, 5 males and 10 females, same data as type and from Puu Kolekole, Molokai, 4,000 ft. July, 1952, (D. E. Hardy and M. Tamashiro). The specimens were collected off the ground litter in very moist habitats along the trails and under the tree ferns.

The type and some of the paratypes are being deposited in the United States National Museum. Paratypes are being placed in the following collections: B. P. Bishop Museum, Hawaiian Sugar Planters' Association, British Museum (Natural History), and the University of Hawaii.

Campsicnemus hoplitipodus new species (Figs. 4a-b)

This is a very small, dark species similar to *C. arcuata* n. sp. in having an enlarged middle tibia which is cleft at the apex and a short basitarsus which terminates in an elongate spine. It is differentiated from this, and other known species of *Campsicnemus,* by the extensive patch of short, stout bristles and the very short basitarsi on the middle tibiae (cf. figs. 2c and 4a).

Male. Compound eyes almost contiguous, at middle of the face; the separation equal to about one-half width of one eye facet. Face whitish and upper and lower portions about equal in length. Front black with a bluish metallic luster. Ocellar triangle half as long as front and one-fourth width of vertex. It has a pair of well developed ocellar bristles. Antennae brownish yellow, paler at base. Apex of third antennal segment narrowly tapered, twice as long as wide, and more than twice length of second segment (fig. 4b).

Thorax bronze to dark brown with bluish green, metallic luster. Pleura concolorous or slightly paler than dorsum of thorax. Each humerus has two bristles, the outer more weakly developed than the inner. There are four pairs of dorsocentral bristles, the posterior pair being out of line and situated towards the lateral margins. Acrosticals uniserial and extend half length of mesonotum. There are also one pair of posthumeral, one pair of presutural, and two notopleural bristles. Scutellum with a pair of marginal bristles. Halteres yellow.

Wings hyaline. There is a long costal bristle near base of wing. The m crossvein is oblique and less than half length of distal portion of veins $M_{3+4} + Cu_1$.

Legs yellow except for middle and hind coxae which are brown. Forelegs void of any conspicuous bristles. *Mesothoracic legs:* Ventral surface of femur lined with long bristles. Tibia slightly longer than femur and cleft at apex. Apical third of tibia greatly thickened and armed on anterior dorsal margin with a clump of dense, short spines. Venter bristly, with a moderately stout preapical bristle. Basitarsus as wide as long, less than one-fourth length of following segment and terminates in a long, black curved spine (fig. 4a). Second tarsal segment one-third as long as tibia and third segment two-thirds as long as second. *Metathoracic legs:* Hind femur has a row of ventral bristles which are not as long as those on middle femur. Tibia has two apical bristles. Basitarsus one-fifth as long as tibia; second tarsal segment slightly longer than basitarsus.

Abdomen dark brown to black.

Length: body, 1.7 mm.; wings, 2.0 mm.

Holotype male, Mt. Tantalus, Oahu, 2,000 ft. elevation (21° 20′ N, 157° 49′ W) July, 1952 (D. E. Hardy). One paratype male, Kulani, Hawaii, 5,200 ft. elevation, July, 1952 (W. C. Mitchell).

The type, is being deposited in the United States National Museum. The paratype, is in the University of Hawaii collection.

Campsicnemus plautina new species (Figs. 5a-d)

This species will run to couplet 26 in Parent's key (loc. cit.) but it distinctly differs from both *C. calcaratus* Grimshaw and *C. putillus* Parent by having strongly flattened second and third tarsal segments on the forelegs.

Male. Junction of compound eyes approximately equal to length of four eye facets. Visible portions of face yellowish white. Front shining, bluish black. There are two well developed ocellar bristles. Postocular bristles short and black. Antennae yellow with pubescent aristae. Second antennal segment has a crown of black setae at apex. Third segment rounded at apex and wider than long (fig. 5d).

Thorax ochraceous. Two brown lateral stripes extend from anterior pair of dorsocentral bristles to base of scutellum. Stripes narrow at anterior ends and expanded laterally to sides of mesonotum at bases. Alined with the two lateral stripes are four pairs of dorsocentral bristles, the posterior pair slightly displaced laterally. Acrosticals sparse and present only on anterior part of mesonotum. Two pairs of notopleural, two pairs of scapular, one pair of posthumeral, one pair of presutural, and one pair of supraalar bristles are present. Scutellum with two marginal bristles. Pleura yellow except for a brown spot on pteropleura. A propleural bristle is present just above front coxa.

Wings hyaline with a long costal bristle at base. The m crossvein is one-half as long as distal portion of vein $M_{3+4} + Cu_1$. Legs yellow except for middle coxae which are largely brown. *Prothoracic legs:* Femur and tibia normal. Basitarsus almost one-half as long as tibia. Second and third tarsal segments flattened and twice as wide as the other segments (fig. 5c). *Mesothoracic legs:* Coxa brown with one bristle. Femur slender and tibia straight. Bristles on dorsal surface of tibia as follows: one on basal fourth, one median, two on apical eighth, and one subapical. On the venter, there are several short bristles near apex. The small basitarsus is one-fifth length of following segment and terminates in a long spine. Third segment of tarsus is three-fourths as long as second (fig. 5b). *Metathoracic legs:* Coxa has one bristle and the femur has one preapical bristle. Tibia has four anterior dorsal, two posterior dorsal, and three ventral bristles (fig. 5d). Basitarsus is one-fourth as long as tibia and four-fifths as long as following segment.

Abdomen dark brown with six visible segments.

Length: body, 2.3 mm.; wings, 2.75 mm.

Holotype male, Nuololo Valley, Kauai, 3,400 ft. elevation (22° 8′ N, 159° 41′ W) July, 1952 (D. E. Hardy). There were no females that could be paired with this specimen.

The type is being deposited in the United States National Museum.

Notes on Insects Associated with Lantana in Cuba

By NOEL L. H. KRAUSS

BOARD OF AGRICULTURE AND FORESTRY, HONOLULU, HAWAII

During the spring of 1952 while I was in Cuba searching for various beneficial insects for introduction into Hawaii, some observations were made on insects attacking the tropical American shrub lantana (*Lantana camara*). This plant is an important pest on ranch lands in Hawaii and many other tropical regions. In 1902-03 Albert Koebele sent a number of species of insects from Mexico to Hawaii to help control lantana, and eight of these became established. The insects listed below were found in the vicinity of Havana, except as noted. I am greatly indebted to specialists of the Division of Insect Detection and Identification, U. S. Bureau of Entomology and Plant Quarantine, for all determinations.

THYSANOPTERA

Thripidae

Frankliniella insularis (Franklin). In flowers, February.
Frankliniella 4 spp. in *tritici* group. In flowers, February.
Frankliniella n. sp. In flowers, February.

Phlaeothripidae

Haplothrips gowdeyi (Franklin). In flowers, February.

HEMIPTERA

Pentatomidae

Euschistus acuminatus (Walker). March.
Symphylus caribbeanus Kirkaldy. March.

Coreidae

Jadera sanguinolenta (F.). April, May.

Lygaeidae

Ninyas strabo Distant. On flowers, February, March.
Ortholomus jamaicensis (Dallas). Santiago de las Vegas, March.

Tingidae

Teleonemia vanduzeei Drake. February, March. San Vicente, Pinar del Rio Province, March, heavy infestation causing near defoliation of one plant. Santiago de las Vegas, March. This bug was given starvation tests on various economic plants, and when found unable to survive on any of them, was shipped to Hawaii where liberations have been made during 1952 on the islands of Oahu, Maui and Hawaii. This species can be distinguished from *T. scrupulosa* Stål, which is already established in Hawaii, by its more slender and less pilose antennae.

Anthocoridae
Lasiochilus sp. April.

Miridae
Hyaliodes vittaticornis Bruner. March.
Hyalochloria unicolor Reuter. March.

HOMOPTERA

Cicadellidae
Euragallia sp. March.
Kunzeana sp. March.

Flatidae
Cyarda melichari Van Duzee. March, April, May.

Acanaloniidae
Genus and species unknown. March.

Coccidae
Orthezia insignis Browne. May, on stems.
Pseudococcus sp. March, on stem.
Pulvinaria sp. March, on leaf.

Aleyrodidae
Tetraleurodes mori (Quaintance). March, on leaves.

LEPIDOPTERA

Pyraustidae
Syngamia haemorrhoidalis (Guenée). April, larva feeding on leaf.

Pterophoridae
Platyptilia sp. March, bred from berry clusters.

Olethreutidae
Crocidosema sp. near, but not, **plebeiana** Zeller. March, bred from berries.
Epinotia lantana (Busck). March, April, bred from berry receptacles. This species was described in the genus *Crocidosema* from specimens fom Oahu. It was introduced into Hawaii from Mexico by Albert Koebele.

COLEOPTERA

Phalacridae
Genus unknown. April.

Cryptophagidae
Cryptophagus sp. April. Santiago de las Vegas, March.
Loberus sp. March.

Chrysomelidae
Chlamisus nigritella Suffrian. March.
Cryptocephalus marginicollis Suffrian. March, May.
Cryptocephalus sp. probably **xerampelinus** Suffrian. March.
Longitarsus sp. March.
Octotoma gundlachi Suffrian. March, April, May; scarce. The larvae form large blotch mines in lantana leaves. A chalcid wasp, *Spilochalcis odontotae* Howard, was reared from the pupae; this wasp has not previously been known from the West Indies according to Mr. B. D. Burks.

Anthribidae
Ormiscus sp. March.

Curculionidae
Pyropus sp. March.

DIPTERA

Agromyzidae
Ophiomyia lantanae (Froggatt). March, April. Bred from berries. The following parasites were bred from pupae of this fly during April: *Eulpelmus* sp. (Eupelmidae), *Horismenus* sp. (Eulophidae) and a cynipid, new genus and species. This agromyzid was introduced into Hawaii by Albert Koebele in 1902-03, and has been sent from there to various other countries where it is now established—Fiji, New Caledonia, Australia, Hong Kong, etc. I have found it common in several places in southern California.

The following thrips were collected in lantana flowers at Riverside, California, May 1952: Many *Frankliniella occidentalis* (Pergande), one *F. minuta* (Moulton) and several *Thrips tabaci* Lindeman.

Recent Liberations of Beneficial Insects in Hawaii—II

By PHILIP W. WEBER

BOARD OF AGRICULTURE AND FORESTRY

The following liberations of beneficial insects have been made since the last previous listing was published.[1]

Introductions by the Cooperative Fruitfly Project

Syntomosphyrum indicum Silvestri

The first liberation of this eulophid on Kauai was made at Wailua on Jan. 2, 1951, and on Maui at Kula on Jan. 3.

Opius oophilus Fullaway

Initial distribution of this braconid to the outside islands was made as follows: Pulehu, Maui, Sept. 29, 1950; Waimea Valley, Kauai, Aug. 23; Maalehua, Molokai, Sept. 25; Manakahau, Hawaii, Aug. 23.

Opius compensans (Silvestri)

This braconid from south India was released at Hawi, Hawaii, on Jan. 29, 1951; Makaha, Oahu, Jan. 31; Kalaupapa, Molokai, Feb. 5; Waiakoa, Maui, Feb. 23; and Lihue, Kauai, April 4.

Opius makii Sonan

O. makii was liberated at Lihue, Kauai, on Feb. 28, 1951; Waiakoa, Maui, Feb. 23; Huehue Ranch, Hawaii, March 1; and Makiki, Oahu, March 2.

Opius phaeostigma Wilkinson

A small number of this African species was released at Hawi, Hawaii, on March 16, 1951.

Opius angaleti Fullaway

This parasite of the melon fly from Borneo was first released at Hookena, Hawaii, on May 2, 1951, and Waimanalo, Oahu, on May 3.

Opius cereus Gahan

First introduced in 1936, this Brazilian species was reintroduced in 1951 and liberated at Woodlawn, Oahu, Papohaku, Maui, and Kamuela, Hawaii, on June 15.

Opius anastrephae (Viereck)

Also first introduced in 1936, *O. anastrephae* was liberated in Kalihi Valley, Oahu, on June 13, 1951, and at Hilo, Hawaii, on June 16.

[1] The first paper in this series appeared in the "PROCEEDINGS," 14(2): pp. 327-330, 1951.

Opius sp.

This undescribed species, near *longicaudatus,* has been referred to in the records as "New Caledonia #3." It was first liberated at Lawai, Kauai, and Waiaha, Hawaii, on Dec. 13, 1950; Kamalo, Maui, on Dec. 22; Kalaupapa, Molokai, Feb. 19, 1951; and Kalihi Valley, Oahu, March 20.

Introductions by the Board of Agriculture and Forestry

Apanteles expulsus Turner
Apanteles ruficrus Haliday

These braconids, imported from Fiji for control of phalaenids, were both released at Mokuleia and the Board grounds in Makiki, Oahu, on Feb. 20, 1951.

Pachylister chinensis Quensel

This histerid beetle was introduced from Fiji for control of flies that breed in dung, particularly the hornfly. It was liberated in Kaneohe, Oahu, on May 29, 1951.

Lagocheirus funestus Thomson

Brought from Australia to aid in the eradication of cactus, this cerambycid was first released at Waimea, Hawaii, in September, 1951.

Orius insidiosus (Say)

This anthocorid bug, predacious on eggs and young larvae, was introduced from Iowa and Missouri to help in control of corn earworm. It was first released at Mokuleia, Oahu, on Oct. 4, 1951.

Cyrtorhinus lividipennis Reuter

This mirid bug was introduced from Guam by Fullaway in 1939 to attack the eggs of the corn leafhopper. Apparently the bug failed to become established. It was reintroduced in 1951 and released at Mokuleia, Oahu, on Dec. 26; Omaopio, Maui, Jan. 10, 1952; Kapoho, Hawaii, April 7; Kaumakani, Kauai, April 30; and Honouliwai, Molokai, Sept. 17.

Hister coenosus Erichson
Hister confinis Erichson

These histerid beetles were brought from Puerto Rico to aid in control of hornfly. *H. coenosus* was released at Waikii, Hawaii, on Jan. 16, 1952, and at Waianae, Oahu, on Jan. 22; *confinis* was released at the University of Hawaii dairy in Honolulu on Feb. 15 and at Waikii, Hawaii, on Oct. 7.

Brachymeria robustella (Wolcott)

This chalcid wasp, brought from Puerto Rico to attack phalaenid pupae, was liberated in Manoa, Oahu, on Feb. 15, 1952.

Cycloneda limbifer Casey
Coleomegilla cubensis Casey

These coccinellids, predacious on aphids, were introduced from Cuba; they were released at Kahala, Oahu, on April 22, 1952.

Egius platycephalus Mulsant

This coccinellid is predacious on the bamboo and other scales; it also was introduced from Cuba. It was liberated in Makiki, Oahu, on April 29, 1952.

Hippodamia quinquesignata punctulata LeConte

This aphid predator was introduced from California; it was released at Mokuleia, Oahu, on May 6, 1952.

Ceratomegilla vittigera (Mannerheim)

Also an aphid predator, and introduced from California, this species was liberated at Waiakoa, Maui, on June 6, 1952.

Stethorus picipes Casey

This coccinellid is predacious on mites. It was obtained in California and first released in Foster Gardens, Oahu, on June 12, 1952.

Chilocorus bipustulatus L.

This scale predator was brought from California and was released in Makiki, Oahu, on June 12, 1952.

Adalia bipunctata (L.)
Hippodamia convergens Guérin

These species were introduced many years ago, the first in 1909 and the second in 1896, 1905, and 1910, to prey on aphids but failed to become established. They were again introduced from California and released in Waikiki, Oahu, on June 18, 1952.

Phorocera erecta Coquillett

Obtained from *Amorbia essigana* Busck on avocado in California, this tachinid fly was introduced to attack *Amorbia emigratella* Busck and other tortricids here. It was first liberated on Round Top, Oahu, on June 19, 1952.

Bracon xanthonotus Ashmead

This braconid was obtained from *Sabulodes caberata* Guenée, also on avocado in California, and was released at Kahe Pt., Oahu, on June 27, 1952 in the hope that it might attack the recently established *Anacamptodes.*

Eretmocerus haldemani Howard

This eulophid is a parasite of aleyrodids. It was introduced from California and was first released at Waialua, Oahu, on Aug. 19, 1952.

Typhlodromus sp.

A predacious mite belonging to this genus was introduced from California to attack *Tarsonemus* and other mites. It was first released in Makiki, Oahu, on Oct. 6, 1952.

Teleonemia vanduzeei Drake

This tingid bug was brought from Cuba to aid in the control of lantana. It was first liberated at Hookena, Hawaii, on May 26, 1952; Waimanalo, Oahu, July 1; and Kaupo, Maui, on Aug. 22.

Gonaxis kibweziensis (Smith)

This predacious snail, a member of the family Streptaxidae, was introduced from Kenya to feed on *Achatina fulica* Férrusac. A small number were liberated at Kaneohe, Oahu, on June 3, 1952.

Tefflus hacquardi de Chaudoir

This is a large carabid beetle which was found attacking *Achatina* in Kenya. It was liberated in Kaneohe some distance away from the *Gonaxis* on the same date.

According to Alan P. Dodd, of the Queensland Department of Lands, who did the early work in biological control of cactus, the species of *Moneilema* introduced by the Board in 1950 should be *armata* LeConte, not *crassa* LeConte ("PROCEEDINGS," 14: 327, 1951).

Two Sarcophagid Flies New to Hawaii

By HAROLD R. DODGE, SCIENTIST (R)

COMMUNICABLE DISEASE CENTER, PUBLIC HEALTH SERVICE
FEDERAL SECURITY AGENCY, ATLANTA, GEORGIA

The following two species have recently been received in material submitted by Drs. D. E. Hardy and C. R. Joyce. The first is apparently undescribed and obviously an immigrant, thus suggesting its specific name.

Pachyophthalmus alienus, new species (figs. 1-4)

Diagnosis. Length 7-8.6 mm. (males average larger than females). This, the first miltogrammine fly known from Hawaii, is easily distinguished from the other sarcophagids of the region by the bare arista, concave occiput, hind coxae bare posteriorly, infrasquamal setulae absent, and the presence of two rows of hairs on each parafrontal in addition to the usual row of bristles.

Male. Front .20 of head width; outer vertical bristle more than half as long as the inner; ocellars very weak; frontal row of about 13, ending before the antennae; on each parafrontal outside the frontal row, two more rows of much shorter hairs; antennae black, short, segment 3 one-fourth longer than 2; arista bare, the basal 2 segments together twice as long as their diameter, segment 2 thrice as long as 1, segment 3 with basal thickening less than one-third length of segment; vibrissal axis seven-eighths as long as antennal axis; parafacials yellow, bare; palpus dark, slender, with sparse hairs ventrally; genae and back of head entirely black-haired; occiput concave.

Thorax large in proportion to abdomen, grey, with 3 black stripes; chaetotaxy: acrostichals 0:1; dorsocentral 1:2, the posterior in a row spaced for four, the anterior a small presutural; intraalars 1:1; supraalars 1:2; humerals 2; posterior callus 2; scutellars 3 strong marginals, no apical, 1 weak discal; notopleurals 2, with numerous coarse setules; sternopleurals 2, or with a weak third; prosternum, propleuron, hind coxa posteriorly, infrascutellum, and postalar walls bare; posterior spiracle open, rounded, fringed with whitish hairs.

Wing with costal spine absent, base of vein 3 with 1-4 setules, costal sections 1-6 respectively, 2.5/4.1/1.3/6.2/1.8/.7.

Legs dark, small, the tarsi not modified; chaetotaxy: fore tibia with 2 posterior; mid tibia with an antero-dorsal and antero-ventral at middle and 2 posterior; hind tibia with an antero-dorsal entire row of about 14, of which the apical 5 or 6 are slightly smaller and more recumbent.

Abdomen dark, with greyish pollinose pattern, small; chaetotaxy: median marginals on tergites 1 and 2 (no exceptions in type series); median row on tergites 3-4; genital aperture slit-like, fifth sternite V-shaped, the lateral arms sparsely setulose; genital tergites dark, sparsely haired, the first with a pair of large setae near base; spiracles 6-7 close to each other, in membrane just behind the ventral angles of first genital tergite. Genitalia as figured; penis largely membranous with darkened, paired internal structure apically, the apex laterally barbed; anterior clasper bare, connected externally by a broad thin sclerotized band; posterior clasper with a single large seta; sperm pump sclerite with a thickened basal section and poorly developed distal section.

Female. Similar to the male but with parafacials grey, front narrower (.17 of head in allotype), and wings slightly shorter (average of four, male wing .56 longer than thorax, female wing .47 longer than thorax).

Puparium. Anterior spiracle 4-lobed; posterior spiracles not in a concavity, peritreme complete, button ventral, slits 3 as usual, the inner pair nearly vertical, their axes slightly convergent ventrally.

Holotype male and allotype female, Oahu Country Club, Honolulu, T. H. March, 1952, ex *Eumenes* nest (C. B. Keck), Type No. 61733, U. S. National Museum, by courtesy of Dr. Hardy.

Paratypes 3 males, 11 females with data identical to holotype; 1 male Honolulu, Oahu June, 1952 (D. T. Fullaway). Six specimens retained in Communicable Disease Center collection; the remainder, returned to Drs. Hardy and Joyce, will be deposited in collections of the University of Hawaii, B. P. Bishop Museum, and Hawaiian Sugar Planters' Association.

Other material examined: about 12 immature specimens reared from nests of *Eumenes pyriformis petiolaris* (Schulz), Honolulu, T. H., and Waipio, Oahu, September, 1951 (D. E. Hardy); 1 male, 1 female Honolulu, October 2, 1950, ex *Eumenes* nest (O. H. Swezey) in Hawaiian Sugar Planters' Association collection.[1]

P. alienus, a parasite in the nests of *Eumenes pyriformis petiolaris,* was probably introduced with its host on war material from the New Guinea region according to Dr. Hardy.

This species is distinct from typical European and North American species by the absence of the anterior acrostichal bristles and by the presence of numerous, coarse hairs on the notopleura, in addition to the usual two notopleural bristles. It differs also in genital features, but most closely resembles *P. floridensis* Townsend in this respect. Its relationship to species of the oriental and south Pacific faunas is not known at present. An Australian relative, *Austrometopia burnsi* Malloch, is also a parasite of *Eumenes* and has numerous hairs on the notopleura, but is distinguished by the setulose propleuron.

Sarcophaga gressitti Hall and Bohart (figs. 5-12)

1947 Hall and Bohart, Proc. Ent. Soc. Wash., 50:131, fig.
1951 Bohart and Gressitt, B. P. Bishop Museum Bull., 204:135-6, figs.

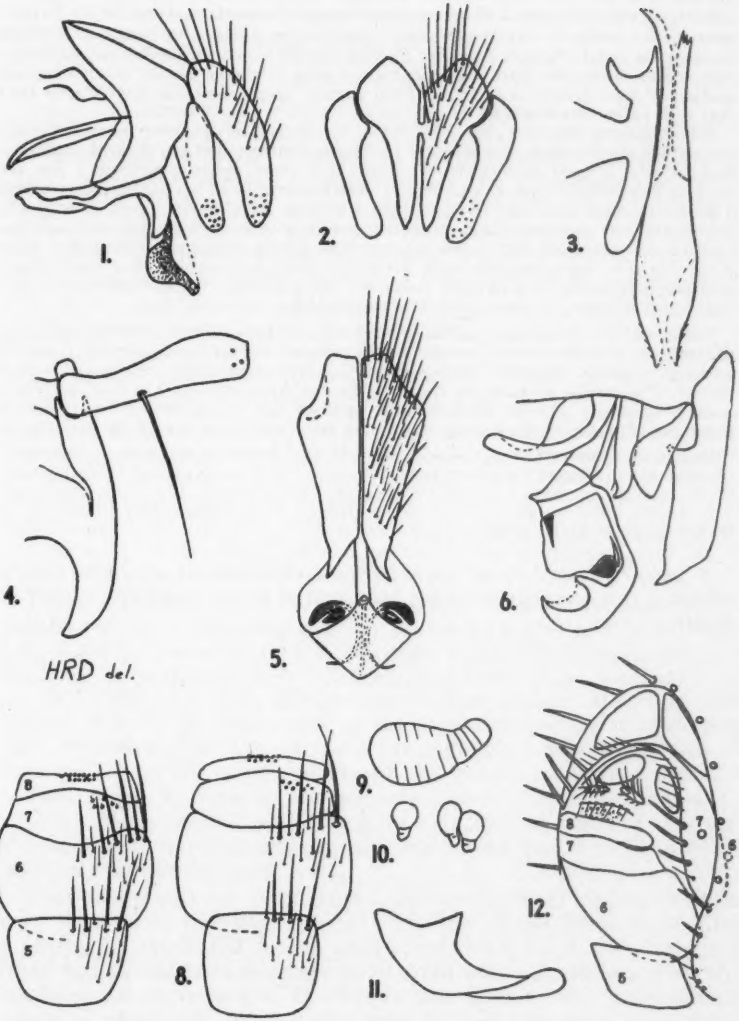
Diagnosis. Distinguished from other Hawaiian species by pilose propleuron and setulose vein 1. Length 7-8 mm. A greyish sarcophagid of ordinary appearance; genital segments black; male hind tibiae villous; chaetotaxy: acrostichals 0.1; dorsocentrals 3:4; intraalars 1:2, supraalars 1:3; humerals 3; posterior callus 2; scutellum with 2 strong marginals, a weak discal, and in male only a small apical; notopleurals 4; sternopleurals 3; median marginals on third abdominal segment.

[1] Dr. Swezey's specimens were the first of this species taken in Hawaii, and are recorded as *Amobia* sp. in these "PROCEEDINGS," (14:221, 1951).

Figs 1-4 Pachyophthalmus alienus sp. n., holotype male genitalia; **fig. 1** composite, lateral view, 72x; **fig. 2** forceps, posterior view, 72x; **fig. 3** penis and left anterior clasper, 96x; **fig. 4** claspers, lateral view (setigerous posterior clasper concealed in fig. 1) 96x.

Figs. 5-12 Sarcophaga gressitti Hall and Bohart, male and female genitalia: **Fig. 5** forceps and penis, posterior view, paratype, 54x; **fig. 6** male genitalia, lateral view, Honolulu, 54x; **fig. 7** female sternites 5-8, ventral view, paratype, 36x; **fig. 8** female sternites 5-8, ventral view, Waimanalo, 36x; **figs. 9 and 10** spermathecae, Waimanalo, 36x (fig. 10) and 96x (fig. 9); **fig. 11** anterior clasper, lateral view, paratype, 54x; **fig. 12** female genitalia, postero-lateral view, Waimanalo, 36x, sternites 5-8 and spiracles 6-7 are numbered.

Note: The numbers indicating the amount of magnification apply only to the drawings as originally made, *not* to the reduced reproductions as they appear on page 133. The numbers are retained at the suggestion of the author, to give an indication of the *relative* sizes of the structures illustrated.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Male genital segments (figs. 4-6, 11) black, first segment grey pollinose, the second shining, both with soft erect hairs only; forceps straight, contiguous on basal .8, the apices divergent and slightly curved inwards; accessory plate triangular, setulose; claspers as illustrated, the anterior clasper flattened; penis 2-segmented, the basal stalk membranous laterally, the distal segment enlarged, largely membranous, a sclerotized strap posteriorly connects with a plate, diamond-shaped in posterior view, which forms the apex of the penis, its lateral arms bent inwards, the apical arm elongated forming a curved claw which encloses a slender internal process, a pair of similar curved processes also arising internally from sclerotized bases and in repose nearly touch each other midway of their length (see fig. 5). Fifth sternite deeply cleft, the lateral arms thickly clad with coarse, short bristles.

Female genital segments (figs. 7-10, 12) black, the genital aperture inverted U-shaped; first genital tergite short, also inverted U-shaped, shortened but not divided or weakened mid-dorsally, fringed with setae of which only three opposite spiracle 7 are stout, spiracle 7 at middle and 6 attached to anterior margin of tergite; 2 pairs of dorsal sclerotized plates separated by first genital tergite; sternites 6-8 fused, 6 larger than 7-8, concave on posterior margin, bristled, pollinose; sternite 7 shining, surface slightly concave, apico-laterally with a few minute setae arising from prominent pores; sternite 8 very narrow, apico-medially with 2 rows of tubercles; sternite 10 a non-sclerotized subtriangular patch of setigerous tubercles; spermathecae 3, each with a constricted base which is more strongly ringed than the oval body.

Variation. The Hawaiian specimens were first thought distinct from typical *gressitti* (Guam) by a difference in the base of the anterior clasper (compare figs. 6 and 11); however, a second Hawaiian male specimen is indistinguishable from *gressitti* in this respect. The female sternites are slightly different (compare shape of fifth sternite and number of strong setae on sixth sternite, figures 7 and 8). In view of the limited material available for study, the significance of these variations cannot be determined.

Specimens examined. Four paratypes, male and female, from Guam, deposited in Communicable Disease Center collection (courtesy of U. S. National Museum through C. W. Sabrosky); 1 male, 1 female, Waimanalo, Oahu, August, 1951, *Scaevola frutescens* (M. Adachi), the female returned to Dr. Hardy; 1 male Honolulu, January 6, 1948, (C. R. Joyce), returned to Dr. Joyce.

S. gressitti is said to be a species most abundant on the open beaches, where it is a scavenger, having been reared from excrement and animal matter.

The Immature Stages of Hawaiian Cerambycidae, with a Key to Larvae

By E. A. J. DUFFY

COMMONWEALTH INSTITUTE OF ENTOMOLOGY, LONDON

The cerambycid fauna of Hawaii is of unusual interest in that it includes one large endemic group, namely the Plagithmysides of the tribe Clytini. This group consists of the genera *Plagithmysus, Callithmysus, Nesithmysus, Aeschrithmysus* and *Neoclytarlus* (=*Clytarlus*). The genera *Callithmysus* and *Clytarlus* of Sharp have been regarded by Aurivillius (1912) as synonymous with *Plagithmysus*. I strongly favour this course and consider that the so-called generic characteristics of *Aeschrithmysus* and *Nesithmysus* as defined by Perkins have been considerably weakened as a result of the subsequent description of additional species which have become connecting forms; particularly this concerns the degree of enlargement of the hind femora.

The plagithmysine group may be distinguished on adult characters from other genera of the Clytini by the absence of transverse folding of the wings (which, therefore, project beyond the abdomen), the strongly attenuated elytra, and the presence of stridulatory organs on two or, sometimes, three different parts of the body. Another character, namely the presence of pronotal carinae or tubercles, is present also in the genera *Neoclytus, Euryscelis* and *Rhopalopachys*.

There has been much controversy and conjecture concerning the possible origin of this unique group of cerambycids. The West Indian genus *Euryscelis* would appear most closely to resemble the plagithmysine group in possessing strongly enlarged hind femora and a carinate pronotum. The wings, however, are normal and folding. Hence it seems feasible that the ancestral stock of the plagithmysine group most probably originated from Central or South America rather than from the Indo-Pacific region whence many of the native plants are presumed to have come. All these species are very closely inter-related and would appear to have arisen from a single introduction. A study of the larval stages has not, unfortunately, revealed any indications as to the probable origin of these cerambycids.

That this group has been remarkably successful is evident from the large number of described species. This high degree of speciation may probably be attributed to the ready availability of a wide variety of hosts and to the lack of competition from other lignicolous insects. It has been the experience of Dr. Swezey that almost every plagythmysine species is associated with a single host. It is indeed most unusual that species which are predominantly dead-wood feeders should prove to be so discriminating, for, generally speaking, species which infest rotting wood are markedly polyphagous (see also Duffy, 1953, p. 35).

The generic larval characteristics of this group, as might be expected, are even less distinct, so much so that it has not been possible to separate the larvae generically. Hence they have been dealt with species by species under the group Plagithmysides. Plagithmysine pupae may apparently be distinguished from those of other Clytini by the presence of at least one large tubercle (usually 2 or 4) on the pronotum and by the position of the mid-femora which extend posteriorly between the wings and elytra, thus separating them. In addition to the plagithmysine group there are two other endemic genera, namely *Parandra* and *Megopis*, both of which are represented by a single species. The genus *Oopsis* is also represented by a single indigenous species.

Another unusual feature of the Hawaiian cerambycid fauna is the comparatively recent and successful establishment of several imported or introduced species (mainly of West Indian or American origin) representative of the Cerambycinae and Lamiinae. These species have also been included in the keys as they are as frequently, if not more frequently, encountered than are the endemic plagthmysine species.

This study has only been made possible as a result of years of patient and painstaking field work on the part of Dr. O. H. Swezey, who has succeeded in collecting and rearing the majority of the Hawaiian Cerambycidae. Biological information concerning the endemic species has not been discussed or summarized in this paper as this aspect has already been dealt with adequately by Swezey, Bridwell and others in various "PROCEEDINGS" of the Hawaiian Entomological Society.

In conclusion I wish to express my thanks and appreciation to E. C. Zimmerman for suggesting that I should undertake this work and to Dr. W. H. Anderson, Dr. E. A. Chapin, and Dr. O. H. Swezey for enabling me to borrow the material for study.

Family Characters of Cerambycid Larvae

Form elongate, usually subcylindrical, occasionally cylindrical or strongly depressed. Cuticle thin, often rather leathery, especially on pronotum; never deeply pigmented or extensively sclerotised, usually greyish or milky white or pale testaceous; pubescent, especially on lateral regions.

Head extensible, usually deeply invaginated into prothorax; occiput large, occipital foramen very large, ventral and often divided into two portions by the tentorial bridge. Ventral surface with a broad transverse bridge formed completely or mainly by the large hypostoma, the front margin of which is never strongly curved or retracted. Clypeus distinct, membranous, usually glabrous. Mandibles short, cutting edge either oblique or gouge-like; never with molar part or prostheca. Antennae usually strongly retractile; second segment usually bearing a tapering hyaline process; generally three-, but sometimes apparently only two-segmented; basal membrane often large and conspicuous. Maxillae protracted but compact; maxillary stipes movable only in one plane; maxillary articulating area distinct, generally fleshy. Labial palpi distinct, conical.

Prothorax large, with a wide collar; mesothorax, metathorax and abdomen narrower; never with hypopleural sclerites; always with a rectangular sclerotised, dorsal plate which is generally more or less glabrous posteriorly but sometimes pubescent or asperate.

Abdomen extended; dorsally, and usually ventrally, bearing fleshy ambulatory ampullae on first six or seven segments; ninth segment often with a sclerotised plate or process or with rigid urogomphi. Anal region nearly always trilobate, exserted.

Legs often vestigial or absent; if present, then widely separated. Never more than four-segmented (excluding unguiculus).

Spiracles annular, bilabiate, with respiratory opening narrow; lips membranous, clothed with setigerous tubercles; peritreme often with marginal chambers.

Note: When larvae are being critically examined it is advisable to remove them from the spirit and place them on a piece of dry filter paper. By absorbing the excess fluid, this makes minute structures such as pleural discs, asperities, setae and ocelli more conspicuous as often they are indiscernible when the larva is wet.

Key to Subfamilies of Cerambycid Larvae

1. Legs absent or vestigial and mandible with an oblique cutting edge (fig. 24). Head distinctly oblong, with sides parallel or converging posteriorly (fig. 24). Maxillae rigid, only movable from stipes; cardo, maxillary articulating area and submentum fused. Pleural tubercle often bearing a sclerotised pit at each extremity (fig. 25). Occipital foramen undivided (fig. 24).....**Lamiinae**, p. 140
Legs usually present and well developed but if absent or vestigial, then mandible with a gouge-shaped cutting-edge (fig. 12). Head transverse to subquadrate, with sides diverging posteriorly (figs. 1-7). Maxillae movable; cardo, maxillary articulating area and submentum distinct. Pleural tubercle without sclerotised pits. Occipital foramen divided by tentorial bridge..... 2

2. Mandible with an oblique cutting-edge (fig. 1). Front margin of frons with the lower boundary usually projecting over the clypeus and the upper boundary dentate or carinate but if not then pronotum asperate posteriorly. Clypeus wide (fig. 1), filling space between dorsal articulations of mandibles. Maxillae with palpi and lobes in same plane as cardo; lobe slender, subcylindrical and densely setose on inner margin (fig. 3). Ninth abdominal segment long, extended. Legs present, well-developed and at least as long as maxillary palpi; unguiculus stout and straight. Six epistomal setae present. Antenna with or without a sclerotised, setose third segment. Prothoracic coxae almost meeting medially. Pronotum sometimes asperate (fig. 4). Dorsal ampullae with two very distinct transverse impressions. Pleural discs present or absent..... 3
Mandible with a gouge-like cutting-edge (fig. 14). Front margin of frons with the lower boundary never projecting over clypeus and upper boundary never dentate or carinate (fig. 14). Clypeus narrow, not filling space between dorsal articulations of mandibles (fig. 14). Maxillae with palpi and lobes curved upward against ventral surface of mandibles; lobes broad and flat, with inner margin glabrous or almost so (fig. 23). Ninth abdominal segment never long and extended. Legs smaller, seldom as long as maxillary palp and sometimes absent; unguiculus slender, usually flagelliform. Four epistomal setae present. Antennae always with a strongly sclerotised, setose, third segment (figs. 18, 19). Prothoracic coxae widely separated. Pronotum never asperate. Dorsal ampullae with posterior transverse impression generally indistinct. Pleural discs present. Palpifer and/or first palpal segment often with a dorso-external process..**Cerambycinae**, p. 138

3. Posterior area of pronotum (fig. 4) and the ampullae asperate. Front margin of frons with lower boundary never projecting over clypeus (fig. 1). Postcondylar carina and subfossal process absent. Pleural discs absent. Antenna always with a strongly sclerotised, setose, third segment (fig. 2). Spiracles with marginal chambers large and extending well beyond outer margin of peritreme (fig. 5). ..... **Parandrinae (Parandra puncticeps** Sharp), p. 141
Posterior area of pronotum and the ampullae without asperities. Front margin of frons with lower boundary projecting over clypeus (fig. 7). Postcondylar carina and subfossal process present (fig. 7). Pleural discs present. Antenna sometimes without a strongly sclerotised, setose, third segment. Spiracles with marginal chambers, if present, very small and not extending beyond outer margin of peritreme..... **Prioninae (Megopis reflexa** [Karsch]), p. 141

Key to Genera and Species of Hawaiian Cerambycid Larvae
Cerambycinae.

1. Dorsal ampullae microscopically spiculate and dull. Ocellar lenses indiscernible. Length up to 44 mm. ..... **(Oemini) Xystrocera globosa** (Olivier) p. 142
Dorsal ampullae not spiculate; usually shining but if dull then microscopically granulate or reticulate. Ocellar lenses distinct (fig. 12). Length up to 30 mm. 2
2. Proeusternum with sculpturation similar to that on posterior part of pronotum (figs. 9, 11). Legs well developed, longer than maxillary palpi. Ampullae microscopically granulate ..... **Callidiopini** 3
Proeusternum without sculpturation as on pronotum. Legs not well-developed, much shorter than maxillary palpi..... **Clytini** 4
3. Front margin of prosternum with a row of about 30 small elongate, brownish tubercles (fig. 9); proeusternum dull, milky white and finely granulate. Abdominal segments 4-7 quadrate to transverse; ampullae scarcely protuberant. ..... **Curtomerus pilicornis** (Fabricius), p. 146
Front margin of proeusternum without a row of tubercles; proeusternum shining, longitudinally striate (fig. 11). Abdominal segments 4-7 strongly elongate; ampullae strongly bilobed..... **Ceresium unicolor** (Fabricius), p. 146
4. Three pairs of ocelli present in a row, laterad and ventrad of antenna (fig. 12). Genae broadly ferruginous (fig. 12)..... **Cyllene crinicornis** (Chevrolat), p. 148
Only one pair of ocelli present (fig. 14) 5
5. Postnotal fold of prothorax, mesonotum and metanotum shining and very finely rugose. Ocellus situated laterad of antenna and not surrounded either posteriorly or ventrally by sclerotisation of gena. Mouthframe feebly sclerotised, testaceous. Ampullae vermiculately rugose anteriorly and smooth and shining posteriorly and with a distinct median transverse impression. Genae with long, fine, curved setae. Usually in *Bambusa*..... **Chlorophorus annularis** (Fabricius), p. 149
Postnotal fold of prothorax, mesonotum and metanotum dull, microscopically granulate. Ocellus situated ventrad of antenna and at least partly surrounded by ferruginous sclerotisation of gena (fig. 14). Mouthframe strongly sclerotised, ferruginous (fig. 14). Ampullae entirely and evenly dull and microscopically granulate (except *Aeschrithmysus*); without a median, transverse impression ..... **Plagithmysine** group, p. 149

Plagithmysine group.

In the following key certain species could not be separated satisfactorily and other species could only be separated on characters likely to vary intraspecifically. In several cases a species was represented only by one or two larvae in rather poor condition, hence until longer series become available for study, this key must be regarded as provisional.

1. Dorsal ampullae shining, vermiculately rugose, devoid of granules ..... **Aeschrithmysus terryi** Perkins
   Dorsal ampullae dull, entirely granulate 2
2. Front margin of hypostoma protuberant or enlarged near gula (figs. 16, 17). Sclerotisation of gena broadly enclosing ocellus 3
   Front margin of hypostoma not or scarcely protuberant or enlarged near gula 7
3. Hypostoma very strongly obliquely striate and front margin dentate (fig. 17). ..... **Plagithmysus newelli** Sharp, p. 147
   Hypostoma not or feebly striate and front margin not dentate (fig. 16) 4
4. Ventral front margin of head with a distinct sclerotised tubercle on acetabulum (in which the *condylus mandibulae* rotates) 6
   Ventral front margin of head without a tubercle on acetabulum 5
5. Ampullae regularly granulate. Front margin of hypostoma strongly protuberant (fig. 16). Mouthframe narrowly interrupted opposite antenna ..... **Plagithmysus blackburni** (Sharp)
   Ampullae with granules irregularly arranged, giving a vermiculate, macro-reticulate effect. Front margin of hypostoma only slightly protuberant ..... **Nesithmysus haasii** Perkins
6. Front margin of hypostoma pitchy ..... **Plagithmysus varians** Sharp
   Front margin of hypostoma ferruginous ..... **Plagithmysus lamarckianus** Sharp
7. Sclerotisation of gena completely enclosing ocellus posteriorly but sometimes narrowly interrupted opposite antenna. Ventral front margin of head without a distinct sclerotised tubercle on acetabulum 8
   Sclerotisation of gena not completely enclosing ocellus posteriorly (fig. 14) 17
8. Dorsal ampullae with granules irregularly arranged, giving a reticulated effect. ..... **Plagithmysus bishopi** Sharp
   Dorsal ampullae with granules regularly arranged 9
9. Sclerotisation of gena narrow and only just enclosing ocellus posteriorly and interrupted opposite antenna 10
   Sclerotisation of gena broadly enclosing ocellus posteriorly and not interrupted opposite antenna 16
10. Size very small, length not exceeding 8 mm. Second antennal segment sub-quadrate (fig. 20) ..... **Neoclytarlus longipes** (Sharp)
    Size much larger, length at least 20 mm. Second antennal segment elongate, at least twice as long as basal width (figs. 18, 19) 11
11. Anterior half of pronotum ferruginous ..... **Plagithmysus bilineatus** Sharp
    Anterior half of pronotum testaceous 12
12. Spiracles rather narrowly oval 13
    Spiracles round or almost round 15
13. Ventral front margin of head without a tubercle on acetabulum. Third antennal segment three times as long as basal width (fig. 18) ..... **Plagithmysus giffardi** Perkins
    Ventral front margin of head with a tubercle on acetabulum. Third antennal segment not more than two and one-half times as long as basal width (fig. 19) 14
14. Supplementary segment of antenna about two-thirds length of third segment. Mandible with a strong tubercle on acetabulum ..... **Plagithmysus sharpianus** Perkins
    Supplementary segment of antenna at least three-quarters length of third segment (fig. 19). Mandible with a feeble tubercle on acetabulum ..... **Plagithmysus kuhnsi** Perkins
15. Third antennal segment about twice as long as basal width (fig. 21) ..... **Callithmysus microgaster** (Sharp), **C. koebelei** Perkins
    Third antennal segment about three and one-half times as long as basal width. ..... **Plagithmysus arachnipes** Sharp
16. Ventral front margin of head with a subconical or blunt but distinct tubercle or swelling on acetabulum. Third antennal segment three and one-half to four times as long as basal width. Sclerotization of gena rather broadly enclosing ocellus posteriorly ..... **Plagithmysus solitarius** Sharp
    Ventral front margin of head without a distinct tubercle. Third antennal segment about twice as long as basal width ..... **Neoclytarlus indecens** (Perkins)

17. Third segment of maxillary palp distinctly longer than second segment. Spiracles narrowly oval 18
Third segment of maxillary palp not longer than second 20

18. Median reticulate area of prosternum with distinct reddish setae ..... **Neoclytarlus nodifer** (Sharp)
Median reticulate area of prosternum with pale golden setae 19

19. Second antennal segment about one and one-half times as long as basal width. Inner angle of maxillary lobe very strongly rounded (fig. 23) ..... **Neoclytarlus filipes** (Sharp)
Second antennal segment about twice as long as basal width. Inner angle of maxillary lobe acutely angular (fig. 22) ..... **Plagithmysus cristatus** (Sharp), and **Neoclytarlus dodonaeae** Swezey

20. Third antennal segment about three times as long as basal width 21
Third antennal segment about twice as long as basal width ..... **Nesithmysus bridwelli** Perkins

21. Sclerotization of gena beneath and posterior to ocellus distinctly ferruginous and as darkly pigmented as mouthframe (fig. 14) ..... **Plagithmysus muiri** Perkins p. 150
Sclerotization of gena beneath and posterior to ocellus narrow, indistinct, testaceous and not as darkly pigmented as mouthframe ..... **Neoclytarlus lookii** Swezey

Lamiinae

1. Posterior half of pronotum velvety asperate. Gena with a conspicuous transverse furrow immediately in front of ocellus. Hypostoma bearing 2-6 setae on each side of gular region (fig. 24). Epipleurum strongly protuberant on segments 6-8 only. Pleural tubercle with a pair of distinct sclerotised pits (fig. 25). Ninth segment without a caudal process or spine ..... **(Acanthocinini) Lagocheirus obsoletus** Thomson, p. 154
Posterior half of pronotum not asperate. Gena without a transverse furrow in front of ocellus. Hypostoma with only one seta on each side of gular region. Epipleurum strongly protuberant on segments 1-8 (figs. 28, 29). Pleural tubercle with only a single sclerotised pit. Ninth segment usually with a minute caudal process or spine (figs. 28, 29) 2

2. Head with setiferous pores on frons longitudinally impressed; sides parallel, and abruptly constricted behind middle. Hypostoma with anterior part steeply sloping down to front margin, which is in a lower plane than that of hind margin. Antenna with third segment three times as long as broad, as long as second segment. Hypostoma not granulate. Length up to 36 mm ..... **(Mesosini) Coptops aedificator** (Fabricius), p. 155
Head with setiferous pores on frons not longitudinally impressed; sides strongly converging posteriorly, broadly and feebly constricted behind middle. Hypostoma flat, with front margin in same plane as hind margin. Antenna if three-segmented, then third segment at most slightly longer than broad. Hypostoma microscopically granulate. Length up to 21 mm 3

3. Antenna 3-segmented, the second segment with a subquadrate, sclerotised third segment and a conical, hyaline supplementary process (fig. 27). Sides of head roundly divergent for anterior half, broadly constricted for posterior half. Hypostomal sutures incurved posteriorly ..... **(Niphonini)** 4
Antenna two-segmented, the second segment bearing a conical hyaline process only. Sides of head parallel for anterior half, not constricted for posterior half. Hypostomal sutures straight ..... **(Pericoptini)** 5

4. Posterior part of ninth abdominal tergite with several long pale setae and a minute, blunt, median spine of a diameter scarcely exceeding that of the basal part of the setae ..... **Pterolophia camura** Newman, p. 156
Posterior part of ninth abdominal tergite with a few long pale setae only ..... **Prosoplus bankii** (Fabricius), p. 156

5. Ninth abdominal tergite with a small median, tubular, sclerotised process near hind margin (fig. 28) ..... **Oopsis nutator** (Fabricius) p. 157
Ninth abdominal tergite with a small, transverse, oval, sclerotised plate (bearing a minute spine) near hind margin (fig. 29) ..... **Sybra alternans** Wiedemann, p. 158

1. Parandrinae

Parandrini

Parandra puncticeps Sharp

Mature larva (figs. 1-5): Length up to 38 mm.; breadth (at prothorax) 8.2 mm. Form cylindrical, rather slender, gradually tapering posteriorly to ninth segment. *Head* (fig. 1) slightly depressed, slightly transverse (maximum head-width 6 mm.), sides feebly rounded. Temples with a shallow constriction behind middle; genae bearing a few, fine setae. Front margin of frons roundly declivous, straight; a transverse row of numerous fine, short setae present behind epistomal setae. Antenna (fig. 2) long, fleshy, scarcely retractile; segment 3 bearing a dome-shaped supplementary segment. Mandible robust, wedge-shaped, pitchy, shining; apex strongly and acutely pointed and directed downward; bearing several short setae on outer face near base; molar area flattened into a striate, trapezoidal plate. Clypeus trapezoidal, leathery, as wide at base as epistoma. Labrum elongate, cordate, feebly sclerotised and fringed with a few fine setae. Maxilla (fig. 3) with shape and setae as figured; lobe elongate, cylindrical, sparsely setose. *Prothorax* with posterior area of pronotum (fig. 4) and median area of eusternum asperate; eusternum distinctly separated from presternum. *Abdomen* with dorsal ampullae present on segments 1-7; each ampulla abruptly and strongly protuberant and finely and sparsely asperate. Pleural tubercle oblong, strongly protuberant, setose; epipleura slightly protuberant on last three segments. Anal lobes compact, each with an oval, rugose area. Legs slender, rather long; unguiculus slender, strongly imbricately spinose for apical half. *Spiracles* of mesothorax broadly oval but not protruding into prothorax; abdominal spiracles with peritreme broadly oval and thick but feebly sclerotised; posterior margin with a row of at least 20 marginal chambers which are largest at middle (fig. 5).

Pupa (fig. 6): Length 21 mm.; breadth 8 mm. *Head* strongly bent beneath prothorax; rounded, glabrous, with two small conical tubercles placed medially on front and vertex respectively. Antennae thick, submoniliform, short, extending to just beyond mid-coxae. Labrum triangular, glabrous. *Pronotum* transverse, with numerous short spines, especially around front and lateral margins. *Mesonotum* glabrous; *metanotum* with a few short spines extending in an oblique row on each side of scutellar groove; scutellum protuberant, fleshy, glabrous. *Elytra* and wings extending as far as fourth abdominal segment. *Abdomen* with tergites one to seven and pleura bearing numerous short, rather stout, ferruginous spines (each with a fine basal seta). Eighth tergite glabrous. Ninth tergite with widely-separated, divergent urogomphi which are very stout, depressed and spinose and truncate apically. Sternites glabrous. *Legs* with hind femora extending to third abdominal segment and hind tibiae almost at right-angles to longitudinal axis of body. *Functional spiracles* present on first six abdominal segments, the seventh pair being closed and nonfunctional; peritreme narrowly oval, thick and scarcely raised above general level of cuticle; posterior margin with a row of about 8 subcontiguous chambers.

Material studied: 2 larvae, 1 pupa, 1 imago, Kumuweia, Kauai, June 25, 1932, ex *Pipturus albidus* (O. H. Swezey); 2 larvae, Kipahula, Maui, August 21, 1929, ex *Acacia koa* (O. H. Swezey).

Biology. See Giffard (1922).

2. Prioninae

Callipogonini

Megopis (Aegosoma) reflexa (Karsch)

Mature larva (figs. 7-8). Length up to 75 mm.; breadth (at prothorax) 13 mm. Form subcylindrical, very robust, gradually tapering posteriorly to ninth segment. *Head* (fig. 7) moderately depressed, slightly transverse (maximum head-width 8.8 mm.). Genae very strongly shouldered, rugose, sparsely setose, darkly pigmented. Mouthframe strongly sclerotised, rugose, narrowly pitchy. Frons ferruginous anteriorly, becoming testaceous

posteriorly. Front margin of frons comprising a narrow, pitchy, sclerotised, obliquely sloping ridge; upper boundary straight, narrowly carinate and bidentate medially; lower boundary straight, not protruding over clypeus. Postcondylar carina sharply raised. Subfossal process obtusely conical. Antenna three-segmented; second segment barrel-shaped, obliquely truncate apically and bearing a minute sensory organ (supplementary segment ?) and a conical apical segment (fig. 8). Mandible very robust, pitchy, shining with outer face rugose, longitudinally sulcate and bearing about six stout setae. Labrum semicircular, coriaceous and fringed with numerous stout setae. Three distinct ocelli present in a straight row laterad and ventrad of antenna; pigmented spots indistinct, enclosed posteriorly by the strongly sclerotised gena. Gula extremely short; sutures diverging to meet anterior portion of occipital foramen. *Prothorax* transverse, sparsely setose, testaceous; delimited laterally by a pair of grooves; median cleavage line complete but indistinct; faintly transversely rugose and glabrous. Eusternum distinctly separated from presternum by a V-shaped suture. Sternum rugose, glabrous. *Mesonotum* and *metanotum* feebly rugose, glabrous. *Abdomen* with dorsal and ventral ampullae on segments 1-7. Pleural discs distinct only on segments 1-3; each radially striate with a shallow pore. Segments 8 and 9 feebly rugose, the latter large, strongly elongate, with only a few fine scattered setae. Segment 10 trilobed, each lobe strongly protuberant, ovoid and bearing a few fine setae. *Legs* rather short (about as long as maxillary palpus), testaceous and sparsely setose; unguiculus robust, spine-like, not imbricately spinose. Spiracles of mesothorax broadly oval; mesothoracic pair minute; abdominal spiracles with peritreme broadly oval, thick and slightly raised above general level of cuticle.

Material studied: 2 larvae, Kahana, Oahu, February 2, 1929, ex *Pelea*, (O. H. Swezey).

3. Cerambycinae

Oemini

Xystrocera globosa (Olivier)

Mature larva. Length up to 44 mm.; maximum breadth (at prothorax) 7.1 mm. *Head* trapezoidal with maximum head-width 4.9 mm. Genae strongly shouldered. Temples narrowly ferruginous ventrad of antennae and bearing numerous short bristly setae. Sclerotization of mouthframe ferruginous and narrowly interrupted beneath antennae. Antenna with segment 2 about one and one-half times as long as basal width; supplementary process conical, about one-fourth length of segment 3. Mandibles short, broad, entirely pitchy. Labrum transversely oval, with anterior margin very densely fringed with short pale setae. Ocelli indiscernible, probably absent. Hypostoma with front margin broadly and very strongly sclerotised and very faintly transversely striate; sutures distinct, slightly incurved. Gula slightly raised; sutures concave, distinct. Maxillary palpi with segment 3 not longer than segment 2; dorso-external process of palpifer distinctly attenuated. Labial palpi with segment 2 shorter than segment 1. *Prothorax* transverse, slightly wider posteriorly, with numerous very short pale setae and interspersed glabrous spots on lateral regions; pronotum with median cleavage line distinctly impressed; anteriorly testaceous, shining; median area rather coarsely punctate and bearing short setae; posteriorly finely and closely longitudinally striate. Prosternum with a pair of triangular, shining, slightly rugose areas. *Abdomen* with ampullae dull, reticulate, rugose and microscopically spiculate; strongly bilobed, especially those on posterior segments. Pleura microscopically pubescent with a few longer setae. *Legs* distinctly 4-segmented, pale.

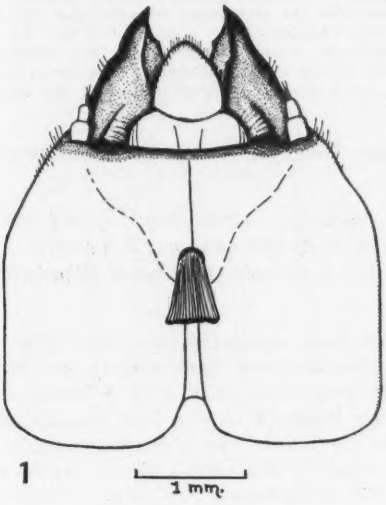
Fig. 1. *Parandra puncticeps* Sharp. Mature larva. Head (dorsal aspect).

Fig. 2. *Parandra puncticeps* Sharp. Mature larva. Apical part of antenna.

Fig. 3. *Parandra puncticeps* Sharp. Mature larva. Apical part of maxilla (ventral aspect).

Fig. 4. *Parandra puncticeps* Sharp. Mature larva. Pronotum.

Fig. 5. *Parandra puncticeps* Sharp. Mature larva. Peritreme of abdominal spiracle.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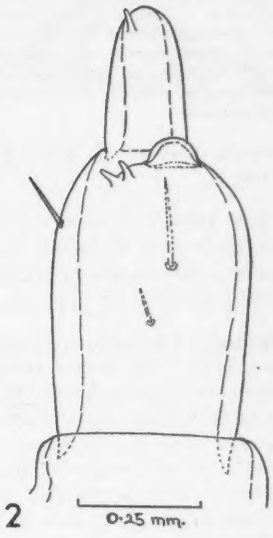
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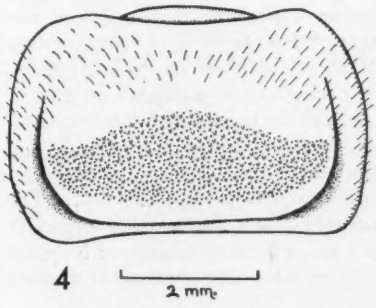
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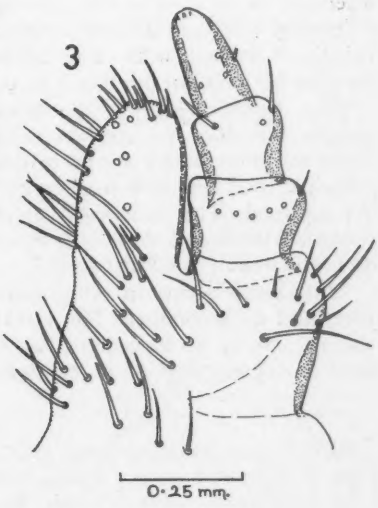
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Pupa. No pupae of this species are available. Gardner (1927) gives the following description: "Antennae long, recurved near the 7th abdominal segment, the apical joint reaching to near the head in the male. Pronotum with a number of soft erect papillae, each papilla with a short cephalad seta. Abdominal tergites 1 to 6 without papillae or setae; 7th tergite with a posterior group of papillae similar to those on the pronotum but smaller; 8th tergite with a slight median posterior projection and with a few papillae."

Material studied: 1 larva, Honolulu, June 11, 1945, ex "monkeypod" tree.

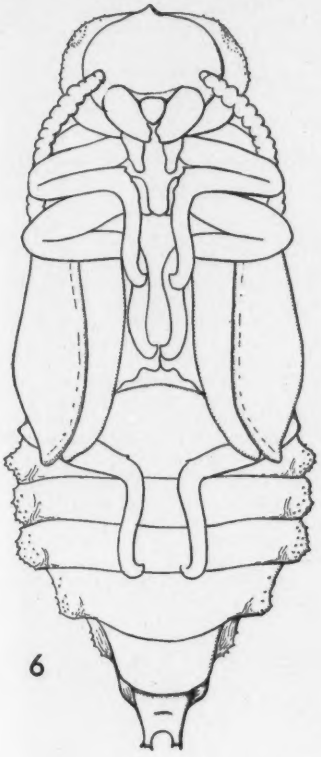
Host plants. *Acacia catechu, A. modesta, Acrocarpus fraxinifolius, Albizzia lebbek, A. lucida, A. moluccana, A. odoratissima, A. procera, A. stipulata, Bauhinia acuminata, Bombax malabaricum, Grewia tiliaefolia, Xylia dolabriformis* (Beeson, 1941).

Biology. The following account has been abstracted from that of Beeson (1941): "The larval tunnels run in the inner bark mainly but also groove the sapwood superficially. In trees with thick bark a heavy infestation reduces more than half the thickness of the bark to dust so that the bark readily separates from the wood. The prepupal tunnel is made at a right angle or an obtuse angle to the surface of the sapwood and then turns downwards or upwards to terminate in a pupal chamber parallel to the long axis of the log. This chamber is lined throughout with a fine deposit of calcium carbonate, very thin so that the inequalities and minor projections on its walls are hardly concealed; the lining is white with some yellowish discolouration especially at the lower end where the larval exuviae rest. The upper end is closed by a thin, smooth, ellipsoidal dome of calcium carbonate about ¼th. of an inch high and 7/16th. of an inch wide. The calcium carbonate is produced in two of the four Malpighian tubules. The pupal period lasts about three weeks."

"The digestive juice of the larvae contains amylase, saccharase and maltase but does not contain cellulase and consequently it does not digest cellulose. There are no mycetocytes in any part of the body. The principal food supply is from other carbohydrates and soluble sugars in the sapwood. The heartwood of *Albizzia lebbek* contains only small traces of starch and sugar and this fact explains why the larval tunnels do not penetrate the heartwood."

"Emergence occurs in every month of the year but mainly in May, June and in September. The larval life is variable and in some individuals may be prolonged for two years, while other individuals of the same brood may develop in less than a year."

Fig. 6. *Parandra puncticeps* Sharp. Male pupa (ventral aspect).
Fig. 7. *Megopis* (*Aegosoma*) *reflexa* (Karsch). Mature larva. Head (dorsal aspect).
Fig. 8. *Megopis* (*Aegosoma*) *reflexa* (Karsch). Mature larva. Apical part of antenna.
Fig. 9. *Curtomerus pilicornis* (F.) Mature larva. Left half of prosternum.
Fig. 10. *Curtomerus pilicornis* (F.) Pupa. Head and pronotum.



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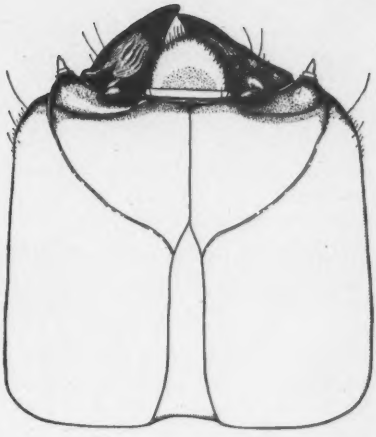

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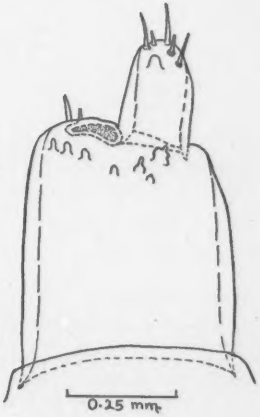

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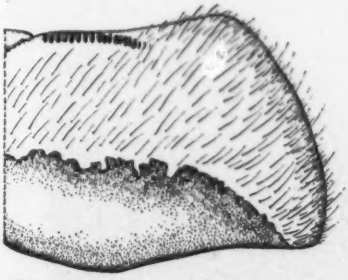

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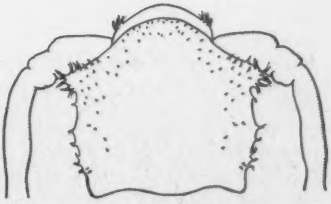

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Economic importance. In India, Ceylon, Malaya and Egypt this species is a pest of shade and ornamental trees, particularly *Albizzia* sp. The less resistant trees may be killed in one season by a heavy infestation.

Callidiopini

Larvae of this genus are remarkable in having the surface of the proeusternum sculptured in the same way as the posterior half of the pronotum.

Curtomerus pilicornis (Fabricius) (=*Cylindera flava* [Fabricius])

Mature larva (fig. 9). Length up to 16 mm.; maximum breadth (at prothorax) 4.2 mm. *Head* transverse, with sides diverging posteriorly. Genae with numerous long, pale, slightly curved setae. Front margin narrowly pitchy. Labrum transversely oval. Ocelli absent. Hypostoma with front margin narrowly ferruginous; sutures indistinct; some long, fine setae present on each side of gula, which is distinctly raised. Maxillary and labial palpi with apical segment longer than penultimate. *Prothorax* with posterior half of pronotum dull, milky white and finely granulate; front margin of prosternum (fig. 9) with a row (interrupted medially) of about 30 small, elongate, brownish tubercles; proeusternum dull, milky white and finely granulate. *Abdomen* with ampullae granulate and glabrous. *Legs* small, slightly longer than segment 3 of maxillary palpi.

Pupa (fig. 10). Length 8-11 mm.; maximum breadth 3.1 mm. *Head* with vertex, which is visible from above, bearing a group of spines immediately above each antenna. Eyes strongly convex, with a row of spines along ventral margin. *Pronotum* with a pair of prominent spinose, lateral tubercles near front margin. *Abdomen* with spines on tergites 1-6 mostly directed anteriorly. Tergite 7 with numerous scattered short spines. Tergite 8 with about 6 short spines. *Legs* with femora strongly clavate; hind femora extending as far as abdominal segment 5. *Functional spiracles* present on segments 1-5 but vestigial pairs present on segments 6 and 7; peritreme broadly oval and moderately thick.

Material studied: 8 larvae, 1 pupa, 1 imago, Honolulu, May, 1928, ex *Acacia decurrens* (O. H. Swezey) : 9 larvae, 3 imagos, Niu Valley, Oahu, September 30, 1928, ex "guava" (O. H. Swezey).

Host plants. *Acacia decurrens, A. farnesiana, Eucalyptus, Datura, Pimenta officinalis.*

Ceresium unicolor (Fabricius) (= *simplex* Gyllenhal)

Mature larva (fig. 11). Length 25 mm.; breadth 4.1 mm. Genae strongly sclerotised and ferruginous behind antennae, with only a few short bristly setae. Front margin of frons narrowly ferruginous. One oval ocellus present laterad and ventrad of antenna. *Prothorax* with posterior half of pronotum shining, longitudinally striate. Front margin of prosternum without tubercles; proeusternum (fig. 11) shining and longitudinally striate as on pronotum. *Abdomen* with ampullae very strongly protuberant both dorsally and ventrally on segments 1-6; segments 4-7 strongly elongate. *Legs* appreciably longer than segment 3 of maxillary palpi.

Fig. 11. *Ceresium unicolor* (F.) Mature larva. Left half of prosternum.

Fig. 12. *Cyllene crinicornis* (Chevrolat). Mature larva. Head (lateral aspect).

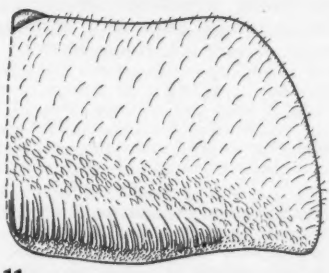
Fig. 13. *Chlorophorus annularis* (F.) Male pupa. Seventh and eighth abdominal tergites.

Fig. 14. *Plagithmysus muiri* Perkins. Mature larva. Head (lateral aspect).

Fig. 15. *Plagithmysus muiri* Perkins. Male pupa (dorsal aspect).

Fig. 16. *Plagithmysus blackburni* (Sharp). Mature larva. Hypostoma.

Fig. 17. *Plagithmysus newelli* Sharp. Mature larva. Hypostoma.



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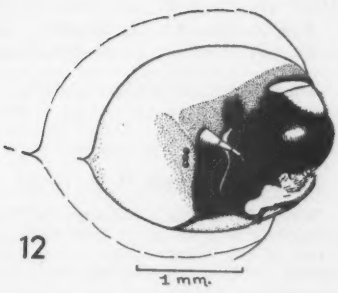

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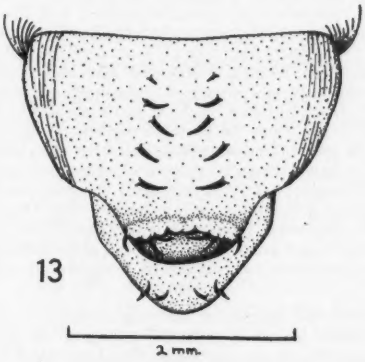

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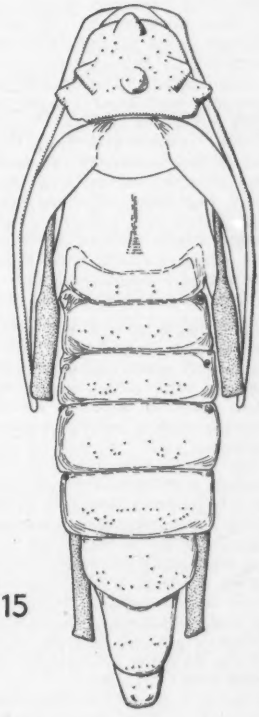

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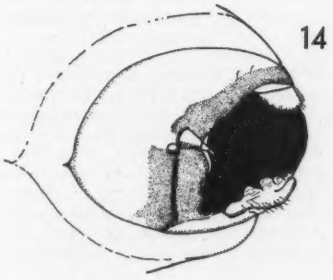

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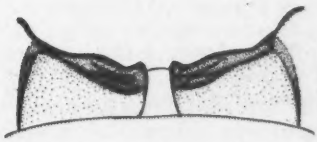

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Material studied: 1 larva, Waimano, Oahu, November 20, 1927, ex *Acacia koa* (O. H. Swezey); 5 larvae, 1 imago, Honolulu, November 27, 1927, ex "croton" (O. H. Swezey).

Host plants. *Pipturus, Acacia.*

Clytini

Cyllene crinicornis (Chevrolat)

Mature larva (fig. 12). Length up to 25 mm.; maximum breadth (at prothorax) 6.7 mm. *Head* with maximum head-width 4.1 mm. Genae gradually narrowed up to mouthframe, smooth, faintly striate and bearing a few pale setae; temples narrowly ferruginous behind ocelli and not as darkly pigmented as front margin of frons. Sclerotisation of mouthframe ferruginous, not interrupted beneath antennae (fig. 12). Antennae with segment 2 at least twice as long as broad; segment 3 three times as long as basal width and about two-thirds as long as segment 2; supplementary process conical, less than one-fourth length of segment 3. Mandibles broad, entirely pitchy; longitudinal impression absent. Labrum transversely oval, fleshy, with long pale setae. Three ocelli present in a row laterad and ventrad of antenna; lens small, convex: pigmented spot indistinct. Hypostoma with front margin broadly ferruginous and strongly transversely rugose; sutures ferruginous, curved. Gula distinctly raised; sutures concave, distinct. Maxillae with lobe entirely glabrous on inner margin; maxillary palpi with segment 3 short, about as long as segment 2; dorso-external process of palpifer much shorter than segment 3 of palpi. Labial palpi with segment 1 much broader than and as long as segment 2. *Prothorax* with long, fine, pale, silky setae on lateral regions; pronotum with similar setae and orange-testaceous anteriorly; posteriorly milky white, and longitudinally striate; median cleavage line faintly impressed. *Abdomen* with ampullae dull, milky white, extremely finely reticulate; median longitudinal furrow broad and shallow. Pleural discs wrinkled, reticulate and rather indistinct. *Legs* distinctly 3-segmented but shorter than maxillary palpi.

Pupa. Length up to 21 mm.; maximum breadth 5.8 mm. *Head* with vertex visible from above, smooth; front transversely striate medially, glabrous; posterior region of temples with a small group of long fine setae. Labrum triangular, glabrous. *Pronotum* slightly transverse, with sides strongly diverging posteriorly and hind angles abruptly right-angled; scattered papillate spinules present especially on anterior region and along sides; disc with a median conical tubercle. *Mesonotum* transversely striate, glabrous. *Metanotum* with a few minute papillae on each side of scutellar groove which is broad, shallow and transversely striate. *Elytra* and wings extending to abdominal segment 4. *Abdomen* with tergites 1-6 each with a transverse band of scattered short spines (each with a basal seta). Tergite 7 elongate, tapering posteriorly with hind margin rounded; bearing a transverse row of 5-6 large spines (which are curved anteriorly) near posterior margin, anterior to which are 2 or 3 pairs of inwardly-curved spines. Tergite 8 transverse, with posterior margin broadly rounded and bearing 4 inwardly curved spines. Segment 9 retracted into segment 8. Sternites glabrous except for a few minute setae around lateral regions. Pleura scarcely protuberant, longitudinally rugose, glabrous. *Legs* with hind-femora extending as far as abdominal segment 5 and lying parallel to longitudinal axis of body. *Functional spiracles* present on abdominal segments 1-5, those on segments 6-8 vestigial; peritreme rather narrowly oval and raised well above general level of cuticle.

Material studied: 7 larvae, 2 pupae, 1 imago, Molokai, February 15, 1928, ex *Prosopis* (O. H. Swezey).

Host plants. *Acacia confusa, A. arabica, Sapindus, Prosopis chilensis, Poinciana regia, Haematoxylon campechianum, Leucaena glauca, Albizzia lebbek, Fraxinus.*

Chlorophorus annularis (Fabricius)

Mature larva. Rather similar to that of *Cyllene crinicollis* (Chevrolat) from which it may be distinguished as follows: Form more slender; length up to 23 mm.; maximum breadth (at prothorax) 4 mm. *Head* with sclerotisation of mouthframe interrupted beneath antenna by a narrow gap. Genae feebly sclerotised and testaceous. Hypostoma with front margin narrowly pale testaceous; sutures pale testaceous. One pair of ocelli present. Antenna with supplementary process elongate, nearly half as long as segment 3. Maxillary palpi with segment 3 slightly longer than segment 2. *Legs* minute, shorter than apical segment of maxillary palpi.

Pupa (fig. 13). Similar to that of *Cyllene crinicollis* (Chevrolat) from which it differs as follows: Pronotum devoid of sublateral papillate spinules. Abdominal tergite 7 with spines smaller and arranged as figured (fig. 13).

Material studied: 15 larvae, 2 imagos, Guam, September 20, ex green *Bambusa* stem (Gomez); 1 larva, Honolulu, May 14, 1929, ex *Bambusa*, (O. H. Swezey); 8 larvae, 1 pupa [no data].

Host plants. *Bambusa, Dendrocalamus strictus, Shorea robusta, Tectona grandis, Sinocalamus* and *Spondias* spp. (Duffy, 1953).

Biology. Oviposition occurs on cut bamboo which has already lost a certain amount of sap. The first-instar larvae bore into the tissues of the walls of the bamboo, making irregular excavations which are packed with powdery wooden particles and frass. The galleries are not delimited by the nodes. The mature larva excavates a cell in the wood in which it pupates. Adults emerge from May to September but principally in June (Duffy, 1953).

Parasites. Hymenoptera. *Eurytoma xylotrechi* Ferrière, *Doryctes bistriatus* Kieffer, *D. brevipetiolus* Kieffer, *D. picticeps* Kieffer, *D. strioliger* Kieffer, *D. tristriatus* Kieffer, *Duportia cincticornis* Kieffer, *Paraglypta tubigera* Kieffer, *Promiscolus sequestriatus* Kieffer, *Scleroderma domestica* Latr. (Duffy, 1953).

Economic importance. Owing to its particular type of habitat, development is often considerably retarded with the result that emergence often occurs after the bamboo has been utilized in the construction of furniture, etc. In India the bamboo structure of thatched roofs and field telegraph posts are frequently extensively attacked by this species. (Duffy, 1953).

Plagithmysine group.

Plagithmysine larvae appear to possess all the major characteristics of the tribe Clytini and so far as the Hawaiian cerambycid fauna is concerned, appear to be closely related to the genus *Chlorophorus* from which they differ as follows: Head with mouthframe strongly sclerotised, ferruginous; ocellus at least partly surrounded by the ferruginous sclerotization of genae. Postnotal fold, mesonotum and metanotum dull, microscopically granulate. Abdomen with ampullae entirely and evenly dull and microscopically granulate (except *Aeschrithmysus*) and without a median transverse impression.

These larvae constitute so homologous a group that individual descriptions would be for the greater part repetitive. The few character-

istics whereby they may be distinguished from each other are evident in the key. For the sake of completion, however, a detailed description is given of the larva and pupa of a typical plagithmysine species as follows:

Plagithmysus muiri Perkins

Mature larva (fig. 14). Length up to 25 mm.; maximum breadth (at prothorax) 5.5 mm. *Head* with maximum head-width 3.7 mm. Genae gradually narrowed up to mouthframe, smooth, faintly and sparsely striate and bearing numerous short, bristly, reddish setae; sclerotisation beneath and posterior to ocellus ferruginous, as dark as mouthframe and not completely enclosing ocellus (fig. 14); temples testaceous behind ocelli. Sclerotisation of mouthframe broadly ferruginous, not interrupted beneath antennae. Antennae with segment 3 about 3 times as long as basal width. Mandibles broad, entirely pitchy with longitudinal impression absent. Labrum transversely oval, fleshy and fringed with rather long pale setae. One pair of ocelli present immediately ventrad and laterad of antenna; lens rather large, oval, protuberant; pigmented spot distinct. Hypostoma with front margin rather broadly ferruginous and very feebly bilobed; sutures ferruginous, incurved; gula feebly raised, with sutures concave, rather indistinct. Maxillae with lobe entirely glabrous on inner margin; maxillary palp with segment 3 not longer than segment 2. Labial palpi with segment 1 much broader than and longer than segment 2. *Prothorax* with lateral regions micro-pubescent and bearing numerous short pale setae; pronotum bearing numerous rather long pale setae along anterior and lateral margins; anterior half shining, orange-testaceous; posteriorly dull, testaceous, longitudinally and irregularly striate and entirely micro-granuate; median cleavage line distinctly impressed. Abdomen with ampullae dull, milky white, extremely finely granulate; median longitudinal furrow broad and shallow. Pleural discs slightly wrinkled, reticulate and indistinct. *Legs* 3-segmented, minute, not longer than apical segment of maxillary palpi. *Spiracles* with peritreme rather narrowly oval and testaceous.

Pupa (fig. 15). Length up to 21 mm.; maximum breadth 6 mm. *Head* with vertex visible from above; vertex, front and genae smooth, glabrous; labrum triangular, thick and glabrous. *Pronotum* quadrate with acutely-pointed and slightly upturned lateral tubercles; disc with 4 strongly protuberant, conical tubercles and scattered spinules as figured. *Mesonotum* and *metanotum* smooth and glabrous; scutellar groove shallow and faintly transversely striate. *Elytra* and wings extending laterally to abdominal segment 4. *Abdomen* with tergites 1-6 partly mirco-spiculate and each bearing a transverse irregular group of short stout, ferruginous spines (each with a subapical seta and tuberculate basally). Tergite 7 elongate, tapering posteriorly and hind margin strongly rounded; bearing a transverse row of rather stout spines near hind margin, anterior to which is a similar group of slightly smaller spines. Tergite 8 subquadrate bearing medially one or two pairs of strongly incurved spines. Tergite 9 fleshy, protuberant. Sternites glabrous. Pleura scarcely protuberant, longitudinally rugose, glabrous. *Legs* with mid-femora lying laterally to body and extending posteriorly between elytra and wings, thus separating them; hind-femora extending as far as abdominal segment 7 and lying parallel to longitudinal axis of body. *Functional spiracles* present on segments 1-6, those on segments 7 and 8 vestigial; peritreme rather broadly oval and thick, testaceous and slightly raised above level of cuticle.

Fig. 18. *Plagithmysus giffardi* Perkins. Mature larva. Apical part of antenna.

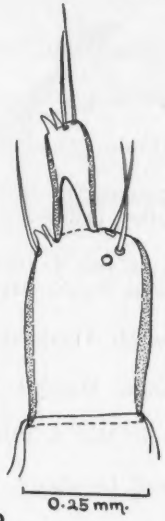
Fig. 19. *Plagithmysus kuhnsi* Perkins. Mature larva. Apical part of antenna.

Fig. 20. *Neoclytarlus longipes* (Sharp). Mature larva. Apical part of antenna.

Fig. 21. *Callithmysus koebelei* Perkins. Mature larva. Apical part of antenna.

Fig. 22. *Plagithmysus cristatus* (Sharp). Mature larva. Apical part of maxilla (ventral aspect).

Fig. 23. *Neoclytarlus filipes* (Sharp). Mature larva. Apical part of maxilla (ventral aspect).



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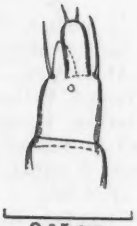

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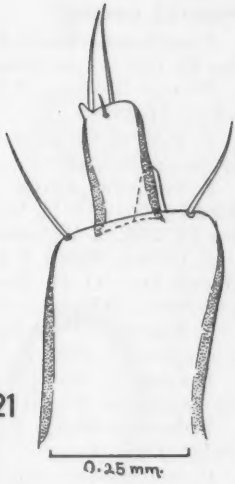

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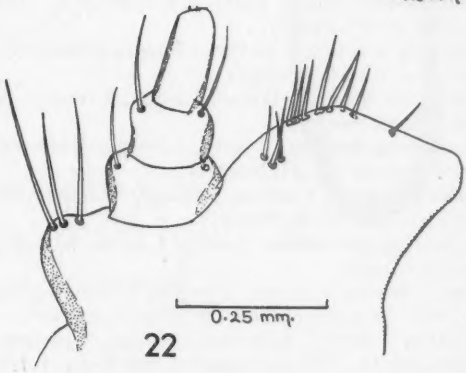

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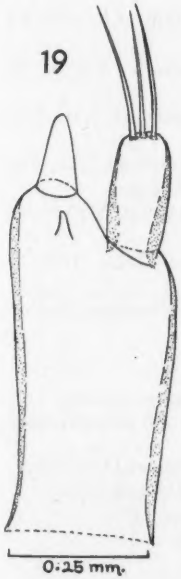

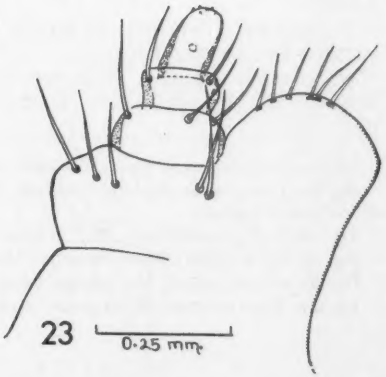

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Material studied:

Plagithmysus muiri Perkins, 3 larvae, 1 pupa, 2 imagos, Oahu, November 13, 1934, ex *Sideroxylon* (O. H. Swezey).

P. newelli Sharp, 1 larva, Maui, March 5, 1947, ex *Nicotiana glauca* (K. L. Maehler).

P. giffardi Perkins, 1 larva, 1 imago, Kilauea, Hawaii, October 14, 1929, (O. H. Swezey).

P. solitarius Sharp, 5 larvae, 1 imago, Oahu, January 26, 1930, ex *Elaeocarpus* (O. H. Swezey); 3 larvae, Mohiakea Valley, Oahu, September 11, 1932 ex *Metrosideros* (O. H. Swezey).

P. varians Sharp, 2 larvae, 1 imago, Kilauea, Hawaii, July 4, 1934, ex *Acacia koa* (O. H. Swezey); 4 larvae, 1 pupa, 1 imago, Nauhi, Hawaii, October 2, 1931, ex *Acacia koa* (O. H. Swezey).

P. blackburni (Sharp), 6 larvae, 2 pupae, 1 imago, Mt. Hualalai, Hawaii, July 31, 1929, ex *Sophora* (F.X.W.).

P. cristatus (Sharp), 10 larvae, 1 imago, Kalauao, Oahu, March 1, 1931, ex *Acacia koa* (O. H. Swezey).

P. bishopi Sharp, 1 larva, 1 imago, Kilauea, Hawaii, May 4, 1930, ex *Pelea* (O. H. Swezey).

P. lamarckianus Sharp, 4 larvae, Kohala Mts., Hawaii, October 4, 1929, ex *Pipturus* (O. H. Swezey).

P. arachnipes Sharp, 5 larvae, 1 imago, Halemanu, Kauai, July 6, 1932, ex *Acacia koa* (O. H. Swezey).

P. bilineatus Sharp, 5 larvae, 1 pupa, 2 imagos, Kilauea, Hawaii, July 19, 1934, (O. H. Swezey).

P. sharpianus Perkins, 1 larva, 1 imago, Kumuweia, Kauai, March 10, 1928, ex *Pipturus* (O. H. Swezey).

P. kuhnsi Perkins, 3 larvae, 1 imago, Waianae Mts, Oahu, October 14, 1928, ex *Pipturus* (O. H. Swezey).

Neoclytarlus dodonaeae Swezey, 1 larva, Kilauea, Hawaii, August 25, 1945, ex *Dodonaea.*

N. lookii Swezey, 6 larvae, 2 pupae, 2 imagos, Pohakuloa, Hawaii, September, 1951, ex stems of *Chenopodium oahuense.*

N. nodifer (Sharp), 6 larvae, 2 pupae, 2 imagos, Kawaihae Uka, Hawaii, February 11, 1952, ex branches and twigs of *Acacia koaia.*

N. filipes (Sharp), 3 larvae, 1 imago, North Kona, Hawaii, September 1, 1929.

N. indecens (Perkins), 10 larvae, 1 imago, Mt. Kaala, Oahu, July 11, 1929, ex *Smilax* (O. H. Swezey).

N. longipes (Sharp), 20 larvae, 1 pupa, 4 imagos, Halemanu, Kauai, June 12, 1932, ex *Alphitonia* (O. H. Swezey).

Fig. 24. *Lagocheirus obsoletus* Thomson. Mature larva. Head (ventral aspect).

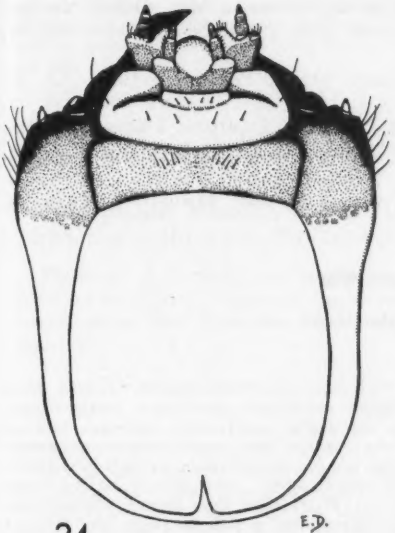
Fig. 25. *Lagocheirus obsoletus* Thomson. Mature larva. Spiracle and pleural tubercle of abdominal segment.

Fig. 26. *Coptops aedificator* (F.) Mature larva. Peritreme of abdominal spiracle.

Fig. 27. *Pterolophia camura* Newman. Mature larva. Apical part of antenna.

Fig. 28. *Oopsis nutator* (F.) Mature larva. Ninth tergite.

Fig. 29. *Sybra alternans* Wiedemann. Mature larva. Ninth tergite.



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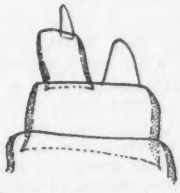

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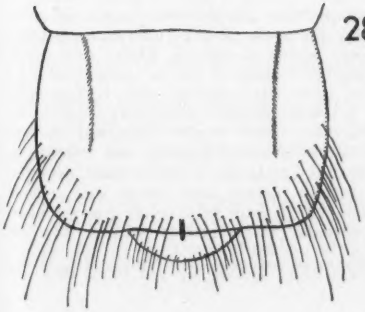

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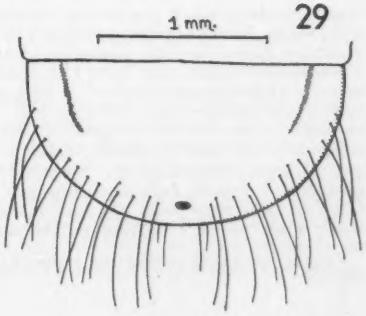

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Nesithmysus bridwelli Perkins, 2 larvae, Waianae Mts., Oahu, November 14, 1937 (O. H. Swezey); 3 larvae, July 23, 1929, ex *Pelea* (O. H. Swezey).

N. haasii Perkins, 1 larva, Kahana, Oahu, February, 1931 (O. H. Swezey).

Callithmysus microgaster (Sharp), 1 larva, 2 pupae, 1 imago, no locality, ex *Bobea* (O. H. Swezey); 1 larva, Kahuku, Hawaii, February 15, 1928.

C. koebelei Perkins, 1 larva, Tantalus, Oahu, January 2, 1928, ex *Pipturus* (O. H. Swezey).

4. Lamiinae

Acanthocinini

Lagocheirus obsoletus Thomson

Mature larva (figs. 24-25). Length up to 34 mm.; maximum breadth 6.5 mm. *Head* (fig. 24) strongly depressed with sides slightly constricted just before middle (maximum head-width 3.1 mm.) and slightly converging posteriorly; antennal foramen open behind; mouthframe ferruginous, very strongly and rather broadly sclerotised; frons with 8 setiferous pores and numerous minute setae. Genae strongly shouldered and protuberant, strongly sclerotised, pitchy and rugose. One pair of ocelli present; lens ferruginous; pigmented spot indistinct. Hypostoma flat, smooth, ferruginous; sutures pitchy and slightly curved; gular region with a pale cleavage line on each side of which is a rugose area bearing 4-6 setae. Antenna 2-segmented, segment 2 bearing a conical hyaline process. Maxillae strongly sclerotised with palpi 3-segmented; segment 3 about two-thirds length of segment 2. *Prothorax* with antero-lateral regions with numerous long ferruginous setae; posterior half of pronotum asperate, with small, scattered, lenticular glabrous areas. *Abdomen* with ampullae with a single transverse impression, a conspicuous pair of lateral furrows and a broad, rather deep longitudinal furrow; non-tuberculate, dull, velvety spiculate. Segment 9 without a caudal spine. Epipleurum protuberant on last 3 segments only. Pleural tubercle (fig. 25) broadly oval, with a pair of sclerotised pits and at least 10 setae. Anus trilobate. *Legs* absent. *Spiracles* with peritreme round, thick, testaceous.

Pupa. Length 21 mm.; breadth 9.5 mm. *Head* with vertex visible from above and deeply excavate between antennae; bearing a few short spines (each with a basal seta) behind base of each antenna; front with groups of 2-4 spines near base of each antenna, half-way between and at inner margin of each eye and at base of clypeus. Antennae extending as far as abdominal segment 5 where (in the female only?) they are strongly recurved and directed anteriorly to terminate alongside mid-coxae. Eyes feebly convex, glabrous. Mandibles each with a spine near middle of outer face. Labrum slightly transverse, with front margin strongly rounded and glabrous or almost so. *Pronotum* strongly transverse, with sides bearing a pair of stout tubercles; numerous short spines are present especially along front margin. *Mesonotum* smooth, with about 6 small spines; scutellum depressed, glabrous. *Metanotum* smooth, with about 4-6 spines on each side of scutellar groove which is shallow. Elytra each with a conspicuous spine near base. Elytra and wings extending as far as abdominal segment 4. *Abdomen* with tergites 1-6 with anterior half with a median oval, tuberculate, spinose protuberance and posterior half with a transverse row (interrupted medially) of short spines. Seventh tergite bearing numerous, much stouter incurved spines. Tergite 8 with similar spines; tergite 9 very short, truncate apically and bearing a pair of large, incurved spines (urogomphi?). Sternites glabrous. Pleura rather strongly protuberant, rugose. *Legs* with fore- and mid-femora clavate, each femur with a row of spines near apex; mid- and hind-femora each with a long tuberculate process near base[1]; hind-femora extending to abdominal segment 4; hind-tibiae with a row of

[1] Similar tuberculate processes are present apparently in all species of Acanthocinini (see Duffy, 1953).

spines; all tibiae more or less at right-angles to longitudinal axis of body. *Functional spiracles* present on abdominal segments 1-6, where they are placed laterally; peritreme rather narrowly oval, moderately thick and slightly raised above general level of cuticle.

Material studied: 8 larvae, 3 pupae, 1 imago, Honolulu, August 22, 1951, ex dead branches of breadfruit tree; 1 larva, 1 pupa, 1 imago, Niu Valley, Oahu, October 30, 1928, ex "kukui" log (O. H. Swezey); 3 larvae, 1 pupa, 1 imago, no data.

Host plants: *Plumeria rubra, Hibiscus,* Allamanda vine, *Araucaria. Euphorbia multiformis, Pseudopanax,* "kukui," Ceara rubber.

Biology. According to Bridwell (1920) this cerambycid attacks unhealthy or injured stems of *Euphorbia multiformis.* After destroying the main stem and branches while the plant is living, it then pupates therein.

Mesosini

Coptops aedificator (Fabricius)

Mature larva (fig. 26). Length up to 36 mm.; maximum breadth (at prothorax) 7.5 mm. *Head* moderately depressed, slightly elongate, widest at middle and abruptly and strongly constricted near posterior third; frontal sutures distinct for entire length; antennal foramen open behind; mouthframe strongly and broadly sclerotised. Frons entirely ferruginous with 8 setiferous pores which are feebly longitudinally impressed; 6 epistomal setae present. One pair of ocelli present; ocellar lens round, feebly convex; pigmented spot rather indistinct. Hypostoma ferruginous, with front margin more darkly so; an abrupt, widely-curved ridge across middle; one pair of distinct setiferous pores present; sutures distinct, pitchy and slightly incurved. Gular region with a pale median cleavage line. Antenna with segment 2 only slightly transverse; segment 3 cylindrical, three times as long as broad, as long as segment 2; supplementary process shorter than segment 3. Maxilla with palpal segment 3 acutely conical, as long as segment 2. Labial palpi with segment 2 cylindrical, about half length of segment 1. Mentum not distinct from submentum. *Prothorax* with pronotum very faintly striate and glabrous. *Abdomen* with each dorsal ampulla with a single transverse, curved furrow and two transverse rows of glabrous tubercles, anterior to which are a few irregularly arranged ones; the two rows are interrupted by the median longitudinal furrow. Ventral ampullae with two rows of tubercles. Segment 9 with a small erect spine (which is not inserted on a sclerotised plate) on middle of posterior margin. Epipleurum protuberant on all segments. Pleural tubercle small, with the ventral sclerotised pit rather large and very distinct. *Legs* absent. *Spiracles* (fig. 26) with about twenty-four marginal chambers.

Material studied: 4 larvae, 2 imagos, Liverpool, Lancashire, August, 1948, ex *Afzelia* imported from East Africa (M. G. de C. Fraser), in the collection of the British Museum (Nat. Hist.).

Host plants: *Acacia arabica, Acacia* sp., *Acrocarpus fraxinifolius, Aegle marmelos, Albizzia lebbek, Bauhinia purpurea, B. retusa, B. vahlii, B. variegata, Bombax malabaricum, Buchanania latifolia, Butea frondosa, Coffea arabica, Careya arborea, Cassia siamea, Cudrania javanensis, Dalbergia paniculata, Excoecaria agallocha, Ficus glomerata, F. religiosa, F.* sp., *Garuga pinnata, Hevea brasiliensis, Holoptelea integrifolia, Lannea grandis, Manihot glaziovii, Millettia auriculata, Mucuna imbricata, Pavetta indica, Pongamia glabra, Pterocarpus marsupium,*

Pueraria tuberosa, Semecarpus anacardium, Shorea robusta, Spatholobus roxburghii, Terminalia belerica, T. tomentosa, Wrightia tinctoria (Beeson & Bhatia, 1939). Fraser (1949) records this species from *Afzelia* sp. and the present writer has recently received a specimen from *Artocarpus* sp.

Biology. According to Beeson and Bhatia (1939) larvae of this species feed either subcortically or actually in the inner bark, and the damage they do to the sapwood is only superficial, for even the pupal cells are constructed almost entirely in the bark. Fraser (1949) confirms this, although he noticed that three larvae under observation had burrowed deeply into the sapwood to pupate; but this change of habit, as he points out, was probably occasioned by the excessive drying-out of the wooden block. The emergence hole is circular, but usually somewhat ragged (owing to the thinness of the bark?). Emergence occurs more or less throughout the year, although the main period in India is in June. The life-cycle normally lasts a year.

Parasites. Hymenoptera: *Scleroderma immigrans* Bridwell.

Niphonini

Prosoplus bankii (Fabricius)

Mature larva. Length 21 mm.; breadth (at prothorax) 4.5 mm. *Head* moderately depressed, elongate, with sides slightly diverging to middle, then strongly converging posteriorly and abruptly constricted at posterior third; frontal sutures indistinct; antennal foramen open behind. Frons smooth, testaceous, with 8 setiferous pores near front margin; 6 epistomal setae present. One pair of ocelli present; lens rather strongly protuberant; pigmented spot indistinct. Hypostoma ferruginous (front margin more darkly so), slightly convex; one pair of distinct setiferous pores present; sutures distinct, slightly incurved. Gular region with a pale median ventral cleavage line. Antenna 3-segmented, the second segment bearing a minute conical, hyaline supplementary segment; segment 3 subquadrate. Maxilla with segment 3 of palp about as long as segment 2. Labial palpi with segment 3 about two-thirds as long as segment 2. *Prothorax* with pronotum very faintly striate and glabrous. *Abdomen* with each dorsal ampulla with a single transverse furrow and two transverse rows of glabrous, moniliform tubercles, anterior to which are a few irregularly arranged ones; these rows not interrupted by median furrow. Ventral ampullae with two rows of tubercles. Segment 9 without a terminal spine (with a few fine setae only). Epipleurum protuberant on all segments. Pleural tubercle small, with only the ventral sclerotised pit distinct. *Legs* absent. *Spiracles* with peritreme broadly oval.

Material studied: 8 larvae, 1 imago, Molokai, November 2, 1928, ex "pigeon pea" stem, (O. H. Swezey).

Host plants: "pigeon pea," *Euphorbia, Crotalaria, Prosopis, Capparis, Erythrina, Citrus.*

Pterolophia camura Newman

Mature larva (fig 27). Length up to 21 mm.; maximum breadth (at prothorax) 4.2 mm. *Head* rather strongly depressed, elongate, with sides slightly diverging to middle then strongly and broadly constricted posteriorly; frontal sutures indistinct; antennal foramen open behind. Frons smooth, broadly castaneous and with 8-10 long setae near front margin; 6 epistomal setae present. One pair of ocelli present, lens oval, protuberant, with pigmented spot distinct. Hypostoma mirco-granulate, with front

margin very narrowly ferruginous; one pair of distinct setiferous pores present; sutures distinct, slightly incurved. Gular region with a pale median cleavage line. Antenna (fig. 27) with segment 2 short, transverse; segment 3 slightly longer than broad and bearing an apical appendage; supplementary process conical, nearly as long as segment 3. Maxillary palpi with segment 3 almost as long as 2. *Prothorax* with pronotum pale testaceous anteriorly and with a fringe of setae across front margin and several long setae laterally; posteriorly smooth and shining. *Abdomen* with each dorsal ampulla with a single transverse furrow and 2 transverse rows of oval, glabrous tubercles surrounded medially and sublaterally by additional tubercles; narrowly but deeply interrupted by the median furrow. Ninth segment with several very long ferruginous setae and with a minute median spine near hind margin. Anal lobes with shorter setae. *Spiracles* with peritreme subcircular, thick.

Pupa. Length up to 14 mm.; maximum breadth 4.5 mm. *Head* with vertex visible from above, smooth, broadly excavated between antennal tubercles and with a pair of setae at base of each of them; front smooth, with about 5 setae around each eye; clypeus with a transverse row of 6 setae; labrum with numerous long setae on each mandible. Antennae short, extending as far as apices of elytra. *Pronotum* slightly transverse, widest posteriorly; disc with a few minute scattered setae. *Mesonotum* with an oblique row of setae on each side of middle. *Metanotum* with scattered short setae on each side of scutellar groove which is broad and shallow. *Elytra* and wings extending to abdominal segment 4. *Abdomen* entirely microscopically granulate; tergites 1-6 each with 2 transverse rows of scattered, short stout spines (each with a basal seta); tergite 7 elongate, tapering posteriorly and with numerous similar scattered setae; tergite 8 short, transverse, with a row of short spines on hind margin. Segment 9 retracted into segment 8. Sternites each with 2 or 3 lateral setae. *Legs* with hind femora extending nearly as far as segment 4; femora with a few fine scattered setae; tarsi glabrous. *Functional spiracles* with peritreme narrowly oval.

Material studied: 3 larvae, 2 pupae, 1 imago, Honolulu, June 6, 1951, ex dead avocado branch.

Ptericoptini

Oopsis nutator (Fabricius)

Mature larva (fig. 28). Length 17 mm.; maximum breadth (at prothorax) 3.1 mm. *Head* rather strongly depressed, elongate, with sides converging behind middle (maximum head-width 1.4 mm.); frontal sutures indistinct; antennal foramen open behind. Frons smooth, with 8 setiferous pores; 6 epistomal setae present. One pair of ocelli present; ocellar lens thick, oval, convex; pigmented spot indistinct. Hypostoma slightly convex, granulate; one pair of setiferous pores present; sutures distinct, ferruginous, slightly curved and converging posteriorly. Gular region with a pale median cleavage line. Antenna 2-segmented, segment 2 bearing a hyaline, dome-shaped process. Maxilla with segment 3 of palp about as long as segment 2. *Prothorax* with antero-lateral regions bearing numerous long, fine, silky setae; posterior part of pronotum shining, faintly longitudinally rugose. Eusternum separated from sternellum by a transverse impression. *Meso-* and *metanotum* dull, microscopically granulate. *Abdomen* with dorsal ampullae slightly bilobed, comprising a pair of oval areas of subcontiguous, moniliform tubercles, a transverse impression and a broad, longitudinal, median furrow. Ventral ampullae with 2 transverse rows of tubercles. Segment 9 with a pair of dorso-lateral, curved impressions and a minute tubular, strongly sclerotised process (fig. 28); setae pale yellowish white. Epipleurum protuberant on all segments. Pleural tubercle small, with only the ventral sclerotised pit distinct. *Legs* absent. *Spiracles* with peritreme round, thin, testaceous.

Material studied: 4 larvae, 2 imagos, Oahu, Manoa Valley, December 28, 1931, ex *Pipturus* (O. H. Swezey).

Host plants. *Pipturus.*

Sybra alternans Wiedemann

Mature larva (fig. 29). Very similar to that of *Oopsis nutator* (Fabricius) from which it differs as follows: Length 12 mm.; breadth (at prothorax) 2.9 mm. *Meso-* and *metanotum* slightly shining, smooth. *Abdomen* with ampullae not bilobed. Tergite 9 (fig. 29) with caudal process bearing a minute transverse, oval sclerotised plate; setae pale ferruginous.

Material studied. 1 larva, 1 imago, Honolulu, January 3, 1952, ex branch of *Hibiscus.*

Host plants. *Hibiscus, Ficus, Cordia,* etc.; polyphagous. Also found in the pseudo bulbs of orchids (*Dendrobium* and *Cattleya* spp.).

REFERENCES

AURIVILLIUS, C., 1912, Coleopterorum Catalogus of Junk and Schenkling. Cerambycidae. Part 39.

BEESON, C. F. C., 1941, The ecology and control of the forest insects. Dehra Dun For. Res. Inst. & Oxford Imp. For. Inst.

BEESON, C. F. C., and BHATIA, B. M., 1939, On the biology of the Cerambycidae (Coleopt.). Indian For. Rec. 5 (1) :1-235, figs. 1-17, pls. 1-8.

BRIDWELL, J. C., 1920, A new lowland plagithmysine Cerambycid from Oahu, with notes on its habits (Coleoptera). Proc. Hawaii Ent. Soc. 4 (2) :314-323.

DUFFY, E. A. J., 1953, A monograph of the immature stages of British and imported Timber Beetles (Cerambycidae). British Museum (N. H.)

FRASER, M. G., 1949, Notes upon the biology of certain species of exotic Cerambycidae (Col.) occasionally imported into Britain. Ent. Mon. Mag. 85:97-99, 2 figs.

GARDNER, J. C. M., 1927, Identification of immature stages of Indian Cerambycidae II. Indian For. Rec. 13:31-61, 4 pls.

GIFFARD, W. M., 1922, Notes and observations on *Parandra puncticeps* Sharp (Coleoptera). Proc. Hawaii Ent. Soc. 5 (1) :118-120.

Susceptibility of the Imported Cabbageworm to Bacillus thuringiensis Berliner[1, 2]

By YOSHINORI TANADA

UNIVERSITY OF HAWAII, COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION, HONOLULU, HAWAII

The infectivity of *Bacillus thuringiensis* Berliner for *Pieris rapae* (L.) was tested at the Laboratory of Insect Pathology, Department of Biological Control, University of California in Berkeley, California. The strain of *B. thuringiensis* used in the present study was furnished by Dr. E. A. Steinhaus. It is believed to be the same strain that Mattes (1927) had isolated and described from the diseased larvae of the Mediterranean flour moth.

Bacillus thuringiensis was first isolated from the larvae of the Mediterranean flour moth, *Ephestia kühniella* Zeller, by Berliner (1911). In 1915, Berliner described the species under this name, and called the bacterial disease "flaccidity." A thorough taxonomic discussion of this species was presented by Steinhaus (1951). Although *B. thuringiensis* Berliner might be considered as a strain of *Bacillus cereus* Frankland and Frankland, a common soil bacterium, Steinhaus (1951) suggested that because of its characteristic and persistent pathogenicity for insects, the name should be retained and, at least for the time being, considered as distinct from *B. cereus*.

Several insect species are susceptible to *B. thuringiensis*. Both Berliner (1915) and Mattes (1927) observed that the larvae of Mediterranean flour moth were highly susceptible to the bacillus. However, larvae of other Lepidoptera, such as certain species of *Nygmia, Lymantria,* and *Thaumetopoea,* and both larvae and adults of certain Coleoptera, such as *Calandra, Tribolium, Dermestes, Tenebrio,* and *Gnathocerus,* were not susceptible according to Berliner (1915). In 1924, Shepherd mentioned that the bacillus was used in Germany to control the cosmopolitan bran beetle *Echocerus cornutus* (Fabr.). Many workers had shown that *B. thuringiensis* (= *B. ephestiae*) was highly pathogenic to corn borer larvae (Metalnikov and Chorine 1929, Metalnikov, Hergula, and Strail 1930, 1931, Chorine 1931, Husz 1931).

Steinhaus (1951) stated that Metalnikov and Chorine in 1929 found the bacillus to be highly virulent for larvae of *Porthetria dispar* (L.), *Aporia crataegi* L., and *Vanessa urticae* (L.), but not for certain grasshoppers, mosquitoes, and beetles. In an extensive study with spore-forming bacteria in 1951, Steinhaus reported that none of the nine strains of

[1] Portion of a thesis submitted as a partial fulfillment for the degree of Doctor of Philosophy from the University of California, Berkeley.

[2] Approved by the Director of the Hawaii Agricultural Experiment Station as Technical Paper No. 279.

Bacillus cereus which were fed to five species of test insects showed any consistent degree of pathogenicity. However, *B. thuringiensis* was highly virulent to *Colias philodice eurytheme* Boisd., moderately virulent to *Junonia coenia* Hübner, *Phryganidia californica* Pack., and *Prodenia praefica* Grote, and least virulent to *Peridroma margaritosa* (Haworth). He also found that a bacillus isolated from a diseased larva of *Aphomia gularis* (Zeller) was highly virulent to *J. coenia, P. praefica,* and *C. philodice eurytheme,* but less so to *P. californica,* and only slightly if at all to *P. margaritosa.* This bacillus was identified by N. R. Smith as *Bacillus thuringiensis.* The sod webworm, *Crambus bonifatellus* (Hulst), was found to be susceptible to *B. thuringiensis* by Hall (unpubl.).

Methods of Study.

The cabbageworms were reared during the summer from eggs laid by field collected adults, and during the winter from eggs laid by laboratory reared adults. The eggs were disinfected by immersing for 90 minutes in a solution of 10 per cent formaldehyde, by weight, according to the method described by Thompson and Steinhaus (1950). After sterilization, the eggs were washed in running tapwater for about 15 minutes to remove the formaldehyde. Then they were placed in sterile half-pint cardboard containers with a vial containing a leaf of either mustard or kale. After the larvae had reached the second instar, they were placed by pairs in sterile containers until they were ready to be used.

Depending on the availability of the cruciferous plants, the cabbageworms were fed either the chicken kale, *Brassica oleraceae* var. *acephala* DC., the smooth leaved mustard, *B. campestris* L., or the rugose leaved mustard, *B. Kaber* (DC.) Wheeler (= *B. arvensis* sensu Rabenh.). In both the treated and control groups, the larvae were reared individually in sterile containers.

Symptoms and Pathology.

In an initial pathogenicity test, 11 fourth instar imported cabbageworms were fed mustard leaves which had been dipped in a suspension of spores of *B. thuringiensis.* Ten fourth instar larvae served as controls. Nine of the treated larvae died during the first 2 days, one on the fourth, and one on the sixth day after infection. All the dead larvae contained large motile rods. In the control group, bacteria other than *B. thuringiensis* apparently caused the death of two larvae.

Two additional tests were conducted with larvae in the early and late fifth instars. In the first trial, 30 early fifth instar larvae were fed leaves that had been dipped in a suspension of spores in blood albumin solution. Thirty untreated larvae of the same age served as controls. During the first 2 days, 23 of the larvae which had been fed treated leaves died, and the remainder died by the fifth day. None of the control larvae died.

The second test was conducted with 20 late fifth instar larvae, which were fed the bacterial spores, and 20 larvae of the same age for the controls. Ten of the 20 control larvae were fed the blood albumin solution and 10 left untreated. None of the control larvae died. All the treated larvae died except for one larva which pupated without feeding on the

spores. Sixteen of the treated larvae died within 2 days, and the remainder died by the fifth day.

The results indicate that *B. thuringiensis* is highly virulent to the imported cabbageworm. Even larvae which feed on the bacterial spores only a day or two before pupation may die from infection. Berliner (1915), however, reported that in *E. kühniella,* if the larvae pupated within 2 days from the time of infection, they were not affected by the disease. The period of infection[3] of the bacterial disease in *P. rapae* is very short, only 1 to 5 days.

According to Steinhaus (1951), the susceptible larvae of most lepidopterous species show similar symptoms following infection by *B. thuringiensis.* The first signs of infection in the imported cabbageworm were a loss of appetite and a decreased response to tactile stimulation. Some larvae showed signs of diarrhea as indicated by the dirty anal segments and by the tendency to stick to the sides of the rearing container by their terminal segments. Others vomited some fluid. Occasionally a dark area or spot appeared on the back or sides of the larva. The larva usually died in an extended flaccid position, but some showed signs of contraction and a tendency to curve backwards. Shortly after death, the body darkened from green to dark brown or black. This discoloration is attributed to secondary organisms (Berliner 1915, Steinhaus 1951). The body contents were soft and somewhat fluid, and the integument was generally firm.

The pathogenesis or course of infection as it takes place within the imported cabbageworm was studied at three different stages. Longitudinal sections were cut from five larvae in the early stage of bacterial infection, from two larvae in the middle to late stages, and from three larvae soon after their death.

Shortly after the spores of *B. thuringiensis* were ingested by the larva, the portion of the mid-gut epithelium that lies posterior to the peritrophic membrane became disorganized (Fig. 1A). Some of the epithelial cells became detached from the wall of the mid-gut. Hemorrhage occurred at the sites where the epithelium was lost, and the blood cells accumulated in the lumen near the exposed intestinal muscles (Fig. 1B). This damage to the mid-gut probably caused the loss of the larva's appetite. At this stage, few vegetative cells of the bacteria were visible in the lumen of the gut. In the larva of the Mediterranean flour moth, Berliner (1915) observed similar destruction of the mid-gut epithelium before the bacteria had increased in numbers, but Mattes (1927) claimed that the bacteria multiplied rapidly within the lumen before the epithelium was damaged.

The bacteria penetrated into the body cavity apparently at the sites where the mid-gut epithelium was destroyed. Berliner (1915) found the same type of penetration in *Ephestia,* but Mattes (1927) believed that this was true only in a very few instances. In *Ephestia,* the bacteria started to enter the hemocoele through the anterior portion of the mid-gut according to Mattes (1927), but in the imported cabbageworm, the bacteria appeared to enter the hemocoele near the posterior region of the

[3] The period of infection is defined as the interval from the time the host feeds on the pathogen until the death of the host from a frank infection.

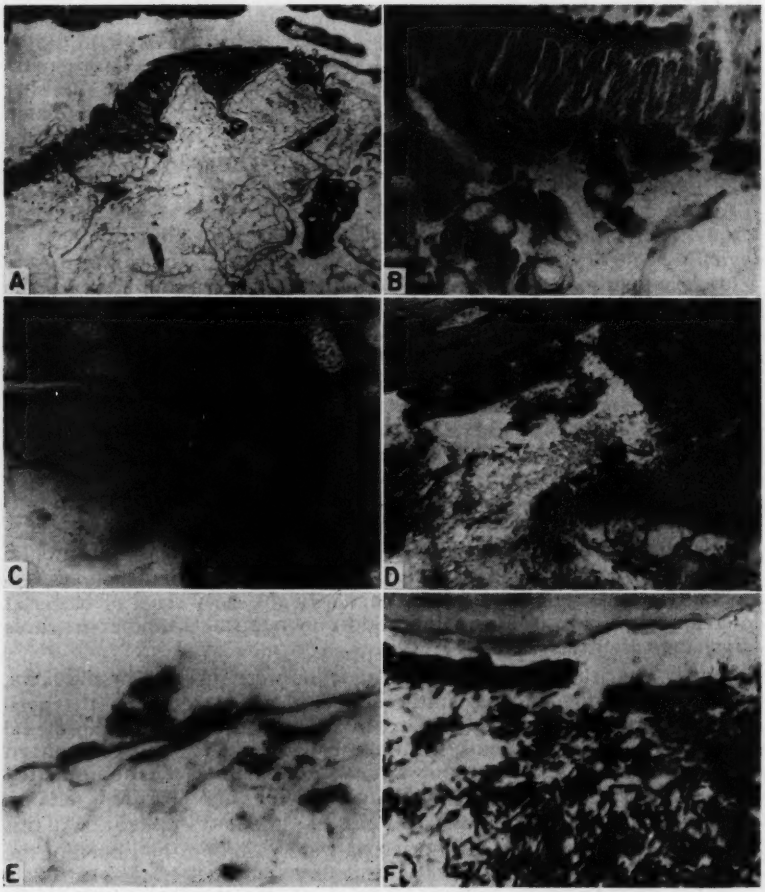

Fig. 1. Longitudinal sections through the tissues of the imported cabbageworm infected with *Bacillus thuringiensis* Berliner. A. Mid-gut epithelium in early stage of infection; note portions of epithelium in the lumen. B. Portion of mid-gut showing cluster of blood cells outside of circular muscle layer where the epithelial cells had fallen off; observe in the lower left corner, the loose cells in the lumen. C. Group of bacilli entering the hemocoele in a region where the mid-gut epithelium had been destroyed; lower left corner is the lumen of the gut. D. Bacilli entering the hemocoele after the mid-gut epithelium has been destroyed. E. Mass of bacteria embedded in the thin remnant of mid-gut wall. F. Intense septicemia; note the hypodermis beginning to break down. A, B, C, D, E, stained with Mayer's acid hemalum and eosin; F, with iron hematoxylin and eosin. A, taken under low power; B, D, under high power; C, E, F, under oil immersion.

mid-gut (Fig. 1C, D). No bacteria were observed entering the body cavity through the gaps between the epithelial cells as reported by Mattes (1927) for *Ephestia*.

As the infection advanced, the destruction of the mid-gut wall progressed anteriorly until most of the epithelium was destroyed. In place of the epithelium, the damaged portions of the mid-gut were lined with a thin necrotic tissue apparently derived from the muscle and neighboring cells (Fig. 1E). The walls of the fore- and hind-guts remained intact until a late stage of infection.

The bacteria multiplied rapidly near the damaged mid-gut and apparently penetrated between the muscle cells into the body cavity. As in the case of *Ephestia* (Mattes 1927) the penetration of the bacteria into the epithelial cells themselves was not observed.

Once the bacillus was in the hemocoele, it increased rapidly in the blood and caused an intense septicemia. Even at this stage, the number of bacteria in the lumen of the mid-gut was not great. When the bacteria entered the hemocoele, the fat tissue was among the first tissues to disintegrate. Mattes (1927) reported that in *Ephestia* the visible damage of the organs did not become apparent until the blood was heavily infected with bacteria, at which time the external symptom of "flaccidity" appeared.

At a very late stage of infection or soon after death, only remnants of the mid-gut epithelium were left. There was an abundance of bacteria in the hemocoele (Fig. 1F) and the lumen of the gut. Besides the fat, other tissues and organs, such as the muscle, hypodermis, trachea, salivary gland, and Malpighian tubules, showed distinct signs of pathology. In general, the cytoplasm of the cells was stained faintly but the nucleus which was usually small, was stained intensely, especially around the margins. The peritrophic membrane became thickened with an occasional mass of bacteria embedded in it.

In *P. rapae*, the breakdown of the tissues apparently took place from the surface that was in contact with the blood. There appeared to be a progressive liquefaction of the surface of the cells and an alteration of the cell membranes. The bacteria might penetrate into the cells before the cells completely broke down.

Among the last tissues to disintegrate were the muscles and nerves. The muscle fiber first lost its typical striated pattern, then became short, broad and irregular, and finally disintegrated. Masses of bacteria penetrated the muscles shortly thereafter. The nervous tissues, especially the ganglia, were also penetrated by bacteria at a late stage. After death, only a few remnants of internal tissues remained among the immense number of bacteria in the hemocoele.

Median Lethal Dose of Bacterial Spores.

Since *B. thuringiensis* was so highly pathogenic to the imported cabbageworm, a study was undertaken to determine the dosage of bacterial spores required to kill 50 per cent of the fifth instar larvae. The bacterial spores were obtained from a plain nutrient agar slant that had been streaked 3 days earlier with a pure strain of *B. thuringiensis*. A

portion of the colony, which had sporulated, was suspended in sterile distilled water by agitating it in a sterile Waring blender. The number of spores in the suspension was determined with a hemocytometer before and after applying the treatments.

A 0.25 ml syringe, manipulated by a micrometer, was used to deliver a measured volume of spore suspension onto discs of mustard leaves measuring one quarter inch in diameter. The drop of spore suspension added to each disc was allowed to dry before it was fed to the larva. The larvae were starved about 5 hours so that they would devour the entire disc before it dried out. They usually ate the entire disc within an hour.

There were three tests. In the first test, five fifth instar larvae were used for each treatment. The treatments consisted of a control and three treated groups of 1, 2, and 3 cubic millimeters of spore suspension. The suspension contained about 8,200 spores per cubic millimeter. Two of the larvae fed the 3 cubic millimeter dosage died from infection with *B. thuringiensis* in 2 days, and one pupa died from a non-spore forming bacterium. In the group treated with 2 cubic millimeters of spore suspension, one larva died in the pupal stage from the bacillus and another died apparently from a non-spore forming bacterium. No larva died in the control or the group treated with 1 cubic millimeter of spore suspension.

The inoculum in the second test contained about 5,000 spores per cubic millimeter. In addition to the control, there were four treatments of 1, 2, 3, and 5 cubic millimeters of spore suspension. Ten fifth instar larvae were used in each treatment. In the treatment with 5 cubic millimeters of spore suspension, two of the 10 larvae died from the bacillus and three from other causes. In the group treated with 2 cubic millimeters of spore suspension, one larva died from the bacillus and one from an unknown cause. The group fed 1 cubic millimeter of spore suspension had one larval death from an unknown cause. None of the larvae died in the control group or in the group treated with 3 cubic millimeters of spore suspension.

The results of the above two trials indicated that the highest dosage of spores used was near the threshold required to kill the larvae. Apparently a concentration of 10,000 to 25,000 spores per larva was needed to cause a lethal infection.

The third test was conducted as in the first two tests, but there were five treatments of 1, 2, 3, 4, and 5 cubic millimeters of spore suspension. Approximately 15,000 spores were present in each cubic millimeter of solution. Each of the five treated groups and the control group contained 10 fifth instar larvae. The larvae were weighed individually on an analytical balance to the nearest milligram. Many of the larvae, after eating only a portion of the disc, lost their appetites and refused to eat

for a day or two. Some of these died from bacterial infection but a few developed into adults. The larvae, which died from infection with *B. thuringiensis,* were killed mostly on the third and fourth day, while none died from the bacillus after the fifth day. The results obtained in the third test are presented in Table 1.

At least 50 per cent of the larvae died from the bacillus when they were fed with 2 cubic millimeters and larger quantities of spore suspension. The dosage of spores needed to kill 50 per cent of the fifth instar larvae was about 30,000 spores per larva or approximately 450 spores per milligram of body weight. As mentioned previously, one of the reasons that a 100 per cent mortality was not obtained in the third test with the higher quantities of spores might have been due to the incomplete consumption of the treated discs by the larvae.

Table 1. The number of spores of *Bacillus thuringiensis* Berliner required to kill fifth instar larvae of *Pieris rapae* (L.). Each treatment had 10 larvae.

Volume spore suspension (mm3)	Total number spores	Dosage	Number dead larvae		Total adults
		Av. no. spores mgm body weight	*B. thuringiensis*	Others	
Control	0	0	0	0	10
1	15,000	340	1	1	8
2	30,000	450	5	0	5
3	45,000	660	6	0	4
4	60,000	760	6	0	4
5	75,000	1,340	7	0	3

Summary

The imported cabbageworm, *Pieris rapae* (L.), is highly susceptible to *Bacillus thuringiensis* Berliner. After ingestion of a lethal dose of bacterial spores, the larvae died in 1 to 5 days. The infected larvae exhibited symptoms similar to those described for other lepidopterous larvae infected with *B. thuringiensis.*

The pathogenesis or course of infection of the disease resembled more closely that described by Berliner than that described by Mattes.

Approximately 30,000 bacterial spores per larva, or about 450 spores per milligram of body weight were needed to kill 50 per cent of the fifth instar larvae.

Acknowledgement

I wish to express my grateful appreciation to Dr. Edward A. Steinhaus for his advice and guidance rendered throughout the study.

LITERATURE CITED

Berliner, E. 1911. Über die Schlaffsucht der Mehlmottenraupe. Z. f. das Gesam. Getreidewesen, 3:63-70.

Berliner, E. 1915. Über die Schlaffsucht der Mehlmottenraupe (*Ephestia kühniella.* Zell.) und ihren Erreger *Bacillus thuringiensis* n. sp. Z. f. Angew. Ent., 2:29-56.

Chorine, V. 1931. Sur l'utilisation des microbes dans la lutte contre la pyrale du maïs. Ann. Inst. Pasteur, 46:326-336.

Hall, I. M. unpubl. The use of microorganisms in the control of the sod webworm. 93 pp. MS thesis in Univ. of California Library, Berkeley.

Husz, B. 1931. Experiments during 1931 on the use of *Bacillus thuringiensis* Berliner in controlling the corn borer. Internatl. Corn Borer Invest. Sci. Rpts., 4:22-23.

Mattes, O. 1927. Parasitäre Krankheiten der Mehlmottenlarven und Versuche über ihre Verwendbarkeit als biologisches Bekämpfungsmittel. (Zugleich ein Beitrag zur Zytologie der Bakterien). Gesell. f. Beförd. Gesam. Naturw. Sitzber. Marburg. 62:381-417.

Metalnikov, S., and **V. Chorine** 1929. L'utilisation des microbes dans la lutte contre la pyrale du maïs. Ann. Inst. Pasteur, 43:1391-1395.

Metalnikov, S., B. Hergula, and **D. M. Strail** 1930. Utilisation des microbes dans la lutte contre la pyrale du maïs. Compt. Rend. Acad. Sci., Paris, 191:738-740.

Metalnikov, S., B. Hergula, and **D. M. Strail** 1931. Utilisation des microbes dans la lutte contre la pyrale du maïs. Ann. Inst. Pasteur, 46:320-325.

Shepherd, D. 1924. Life history and biology of *Echocerus cornutus* (Fab.). J. Econ. Entomol., 17:572-577.

Steinhaus, E. A. 1951. Possible use of *Bacillus thuringiensis* Berliner as an aid in the biological control of the alfalfa caterpillar. Hilgardia, 20:359-381.

Thompson, C. G., and **E. A. Steinhaus** 1950. Further tests using a polyhedrosis virus to control the alfalfa caterpillar. Hilgardia, 19:411-445.

A Microsporidian Parasite of the Imported Cabbageworm in Hawaii[1, 2]

By YOSHINORI TANADA

UNIVERSITY OF HAWAII, COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION, HONOLULU, HAWAII

Introduction

The imported cabbageworm, *Pieris rapae* (L.), has been found parasitized in the field by a microsporidian, *Perezia mesnili* Paillot, in Hawaii. This is apparently the first record of a protozoan infection of *Pieris rapae* in the field. In the laboratory, Steinhaus and Hughes (1949) succeeded in infecting the imported cabbageworm with *Nosema destructor* Steinhaus and Hughes, and Hall (1952) succeeded with *N. infesta* Hall. Hall (unpubl.) also observed larva, pupa, and adult of *P. rapae* heavily infected by another microsporidian in the laboratory. He considered it as a probable new species.

The study on which the present paper is based was conducted at the Laboratory of Insect Pathology, Department of Biological Control, University of California in Berkeley, California. Two shipments of dead larvae of *Pieris rapae* were sent to the writer by members of the Entomology Department, University of Hawaii Agricultural Experiment Station. The first shipment was collected at Kula, Maui and Waimanalo, Oahu in January, 1951. Dead larvae from this collection contained many bacteria, a microsporidian, and a granulois virus. The second shipment of larvae was collected at Waimanalo, Oahu in May, 1952. It was composed of 15 larvae, each of which was placed in a separate vial and killed by freezing in a refrigerator prior to shipment. Twelve of the 15 larvae were found to be infected with the microsporidian discussed here.

Methods of Study

The eggs of the imported cabbageworm were obtained in the summer from field collected adults, and they were obtained in the winter from laboratory reared adults. The eggs were disinfected by immersing for 90 minutes in a solution of 10 per cent formaldehyde, by weight, according to the method described by Thompson and Steinhaus (1950). After sterilization, the eggs were washed in running tapwater for about 15 minutes to remove the formaldehyde. Then they were placed in sterile half-pint cardboard containers with a vial containing a leaf of either mustard or kale. The container was covered with a half of a sterile petri dish. After the larvae had reached the second instar, they were placed by pairs in sterile containers until they were ready to be used.

[1] Portion of a thesis submitted as a partial fulfillment for the degree of Doctor of Philosophy from the University of California, Berkeley.

[2] Published with the approval of the Director of the Hawaii Agricultural Experiment Station as Technical Paper No. 278.

Depending on the availability of the cruciferous plants, the cabbageworms were fed either the chicken kale, *Brassica oleraceae* var. *acephala* DC., the smooth leaved mustard, *B. campestris* L., or the rugose leaved *B. Kaber* (DC.) Wheeler (= *B. arvensis* sensu Rabenh.). The larvae were infected orally with mustard leaves dipped in an infectious inoculum. In both the treated and control groups, the larvae were reared individually in sterile containers. Larvae that died were dissected and the body contents examined under the microscope to diagnose the cause of death.

Symptoms and Pathology

Some of the material from the first shipment from Hawaii was fed to over 50 cabbageworms in order to isolate and propagate the microsporidian, but all the infected larvae died from a granulosis virus infection[3] in 6 to 7 days. In a second trial, the microsporidian spores were purified by centrifugation and fed to 39 larvae, which also died of granulosis. An additional attempt to transmit the microsporidian to the alfalfa caterpillar, *Colias philodice eurytheme* Boisd., was also unsuccessful. Further efforts to isolate the microsporidian from this first shipment were abandoned.

The transmission of the microsporidian to the imported cabbageworm was successful with the use of infectious material obtained from the second shipment of *Pieris rapae*. Two larvae infected with the microsporidian were macerated separately in sterile mortars, and the contents of each diluted with about 25 ml of 0.2 per cent blood albumin solution. One inoculum was fed to 13 larvae and the other to 9 larvae. Smears were made from two or three larvae on the fifth, eighth, and ninth days after feeding on the inoculum. The remaining larvae, 10 in all, were left in their rearing containers until they died. They died 6 to 11 days after infection. On the fifth day after feeding on the microsporidian spores, the tissues of the larvae had very many vegetative stages of the microsporidian and only a few spores. By the eighth and ninth days, the host tissues contained many spores.

In the second trial, another infected larva from Hawaii was prepared into an inoculum as previously and fed to 17 fourth instar cabbageworms. Out of the 15 fourth instar larvae used as controls, 10 were fed leaves treated with blood albumin solution and five were fed untreated leaves. All the controls transformed into adults. In the treated group, 16 of the 17 died as a result of protozoan infection, most of them dying in 9 to 18 days. Two of the dead were pupae. One treated larva matured into an adult female. Tissues of this female contained many microsporidian spores but she appeared normal otherwise. If she had been capable of laying eggs, she might have been able to transmit the microsporidian to her progeny by direct infection of the embryo or by contaminating the surface of the egg with spores when it was laid. Paillot (1933) believed that transmission of microsporidia from adult to offspring occurred often in nature.

[3] An account of this virus appears in this issue of the "Proceedings," pp. 235-260.

The first symptom of microsporidian infection in the imported cabbage worm was a reduced appetite. Shortly after, it became sluggish and occasionally showed signs of diarrhea. As the infection progressed, the larva ate less and less food and for a few days before death very little food was eaten. The life of an infected larva was so greatly prolonged that it was still in the larval stage when the control larvae had transformed to adults. In the late stage of infection, the blood of the larva might become milky. The larva usually turned a lighter green or became slightly mottled, but all larvae that died after a short period of infection were dark green in color. At death, the larva was flaccid and was either extended or slightly contracted. The integument was usually soft but difficult to tear.

When a larva in an advanced stage of infection was dissected, the most striking gross pathology was the reduction in the amount of fat tissues (Fig. 1A). The small amount of remaining fat body usually had a yellow color and a slightly grainy appearance. However, some of the fat bodies were white and showed no granularity. The digestive tract tended to be flaccid and the walls, especially around the mid-gut, had a yellow brown tinge. The walls of the large tracheae appeared to be collapsed. The ventral nerve ganglia stood out distinctly because they were milky white rather than translucent.

When longitudinal sections of an infected larva were examined under the microscope, the spores and the vegetative stages of the microsporidian were found in cyst-like masses within the cytoplasm of the host cells (Fig. 1B, C). These masses apparently consisted either of vegetative stages or spores only. No invasion of the nucleus was observed.

The most heavily infected tissues were the mid-gut epithelium and the Malpighian tubules (Fig. 1B, C, E). The blood cells and salivary glands (Fig. 1D) were somewhat less intensely parasitized. The fat cells apparently broke down rapidly and the remaining fat tissues did not contain very many clusters of the parasite. Moderate to low infections were found in the neural epithelium around the nerve cord and ganglia, the tracheal matrix cells, and the intestinal muscles. Very light infection was found in the muscles (Fig. 1F), hypodermis, tissue around the heart, and the epithelium of the hind-gut. One of the few areas free from parasites appeared to be the epithelium of the fore-gut. Sections have not been made of an infected larva just prior to death and such sections might reveal a much more severe picture than that described above, especially in those tissues that were affected at a late stage. Apparently this microsporidian attacks nearly all the tissues of the host.

At the anterior end of the mid-gut, a great mass of bacteria was observed beneath the peritrophic membrane but outside the mid-gut cells (Fig. 1C). The bacteria might accentuate any diarrheic condition of the host. Such an abundance of bacteria could cause a rapid septicemia once they gained entrance into the host.

The cytopathology was not studied in detail. The abundant parasites within the host cells, especially those of the mid-gut and Malpighian tubules, caused a slight hypertrophy of the cells. In such cells, the nuclei

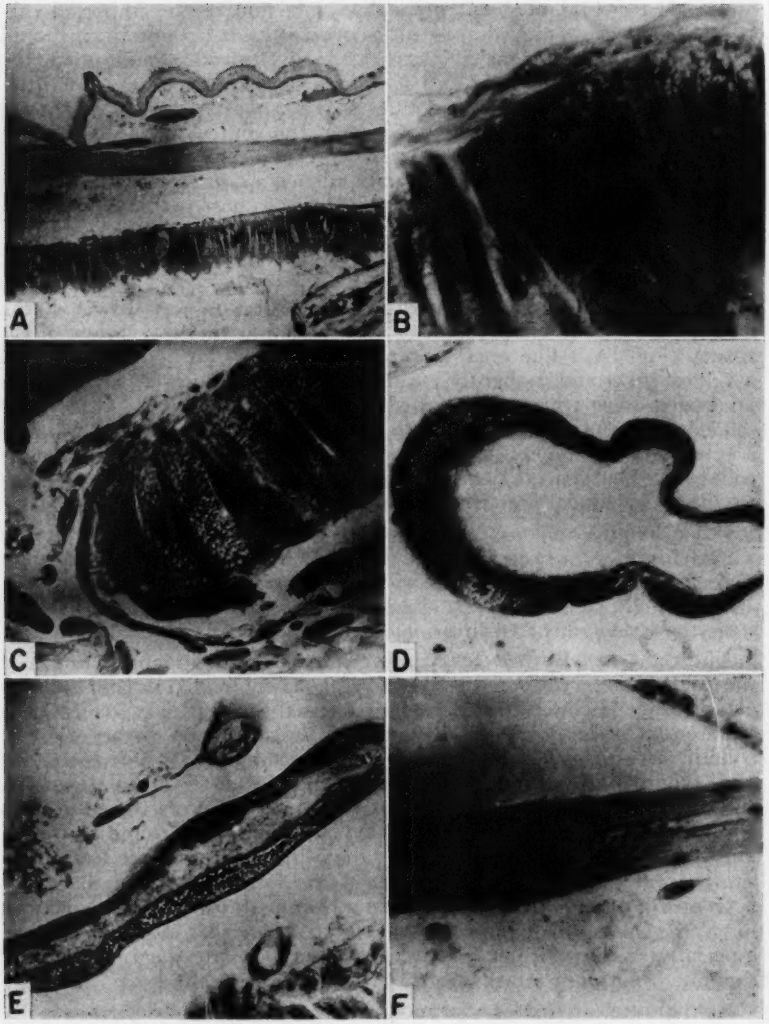

Fig. 1. Sections through tissues of the imported cabbageworm, *Pieris rapae* (L.), infected with the microsporidian, *Perezia mesnili* Paillot. A, portion of cabbageworm, showing the heavily parasitized mid-gut epithelium; note the scarcity of fat bodies in the hemocoele; B, mid-gut; observe cyst-like masses of the parasites in the epithelial and muscular layers; C, anterior region of mid-gut; note the mass of bacteria beneath the peritrophic membrane but outside the mid-gut cells; D, salivary gland; E, Malpighian tubule; F, muscle. Tissues stained with Mayer's acid hemalum and eosin. A, B, C, E, and F are longitudinal sections; D is a cross section. A, taken under low power; B, F, taken under oil immersion; C, D, E, taken under high power.

were displaced to one side. In the fat cells, the nucleus stained densely and contained one or two prominent nucleoli. The cytoplasm of the hypodermal cells stained less densely than normal and some were vacuolated. Their nuclei sometimes appeared irregular and were stained deeply. Apparently no very marked pathologic changes were caused by the parasites. Paillot (1933) noted that the cytotoxic action of microsporidia was very feeble.

Portions of the mid-gut cells with microsporidian spores were found within the lumen of the gut. These spores might emerge with the feces and contaminate the food plant of the host insect. This is probably an important method of transmitting the parasites.

Life Cycle and Description

The different stages of the microsporidian were observed in smears stained with Giemsa solution. The microsporidian spore increased in size and its sporoplasm stained irregularly after it was ingested by the imported cabbageworm. Rarely in some germinating spores, an apparent binucleate amoebula might be seen emerging from them (Fig. 2A, B). A faintly stained strand might have been the polar filament of a germinating spore (Fig. 2B). The amoebulae were small irregular bodies, some bluntly ovoid and binucleate (Fig. 2C), but others were round and mononucleate (Fig 2E). The round form might have resulted from the ovoid form. The ovoid form was usually about 1 by 2.5 microns in size, while the round form was about 2 to 3 microns in diameter. The cytoplasm of the amoebula usually stained heavily.

The amoebula increased in size and became a schizont which was more regular in shape and appeared round in stained smears. The early schizont stages, 2.5 to 4 microns in diameter, were often binucleate (Fig. 2D, G), but some appeared mononucleate (Fig. 2F). Both the cytoplasm and nucleus were rather homogenous and stained densely. The nucleus stained red and the cytoplasm blue with Giemsa solution. Often a more lightly stained area of cytoplasm surrounded the nucleus. The presence of incompletely separated schizonts, each with two nuclei (Fig. 2H), indicated that there was a rapid multiplication of the parasites by binary fission during this stage. Other schizont stages might have 1, 2, or 4 nuclei (Fig. 2I, J, K, L), but schizonts with more than four nuclei were not common. The tetranucleate stages were larger, about 4 to 6 microns in diameter. Their cytoplasm did not stain as densely as that of the smaller stages. Their nuclei had a somewhat diffuse structure and tended to assume very irregular shapes, but generally with one or two clear central areas (Fig. 2L). Occasionally the nucleus appeared like a strand or ribbon (Fig. 2J, N). Some of the tetranucleate forms had a slight indentation probably indicating the future line of cleavage to form two binucleate forms (Fig. 2L). Chains composed of four cells were infrequently found (Fig. 2M, N). Each cell of such a chain had two nuclei or a single ribbon-like nucleus.

The early sporont was represented by a large, elongate, binucleate body about 3 by 7 microns (Fig. 2O). Its cytoplasm stained lightly and appeared vacuolated. The nuclei were very irregular and often appeared

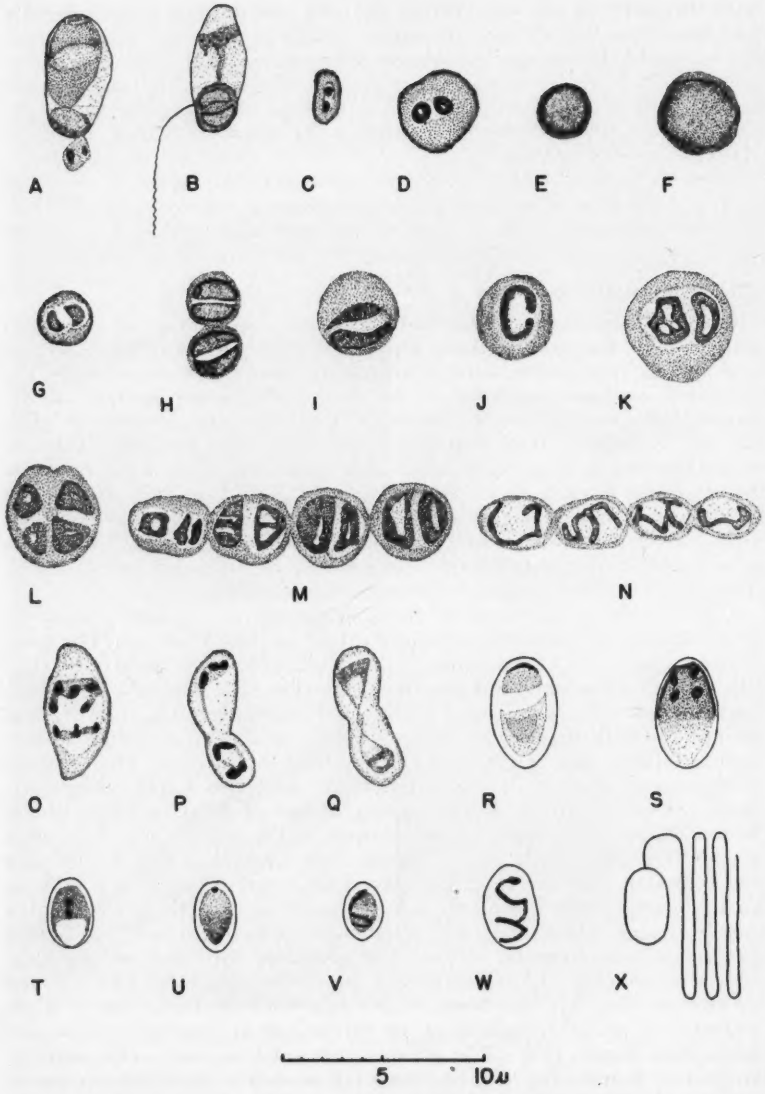

Fig. 2. Stages in the life cycle of *Perezia mesnili* Paillot in *Pieris rapae* (L.). A-B, probably emerging amoebulae from spores; C-N, schizonts; O-Q, sporonts; R-S, young spores; T-W, mature spores, showing coiled polar filaments in V and W; X, spore with fully extruded polar filament.

as several dark staining bodies connected with strands of lighter staining material. Many of the sporonts were slightly curved. This curvature was much more evident during the division of the sporonts to form sporoblasts (Fig. 2P, Q). The formation of the sporoblasts took place after the nuclear division. The sporoblasts usually separated before spore formation, but occasionally double spores were found. However, single spores were possibly formed from undivided sporonts.

The young spores were rather large, measuring about 4 by 6 microns, and had a well stained cytoplasm, with occasionally a dark region at one end (Fig. 2R). Some young spores had several nuclei. (Fig. 2S). As the spores matured, there was a thickening of the spore wall and apparently a reduction in size. The contents of the mature spores were usually stained lightly, and no nucleus was visible. However, an occasional spore was found which had several nuclei (Fig. 2T) or which showed either a single small dark staining body (Fig. 2U), or two such bodies fused, at one end of the spore (Fig. 2V). These bodies are possibly nuclei, but Paillot (1918*a*) did not consider similar bodies in *Perezia mesnili* Paillot as nuclei. Occasionally the polar filament with two to three loops was noticed (Fig. 2V, W).

The measurements of 50 spores varied from 1.4 to 2.7 microns wide by 3.4 to 4.4 microns long, with an average size of about 2 by 4 microns. The polar filaments, which were easily forced out of the spores by applying pressure to the cover slip of a wet mount, were examined under the phase microscope. The length of 20 polar filaments ranged from 33 to 88 microns, with an average length of 54 microns.

Identification of the Microsporidian

Since the sporonts evidently divide into two sporoblasts which develop into spores, the microsporidian apparently belongs to either the genus *Perezia* or *Glugea*. However, as the sporoblasts separate before forming the spores, or perhaps the sporonts form spores directly without dividing, the microsporidian should perhaps be placed in the genus *Nosema*. Paillot (1918*a*, *b*, 1924*b*) encountered similar difficulties in his study of three species of Microsporidia which attacked *Pieris brassicae* (L.), but he provisionally placed them in the genus *Perezia*. The writer has adopted the opinion of Paillot and has placed the species in the genus in which the sporonts form two spores.

The principal difference between *Perezia* and *Glugea* lies in the reaction of the host cell to the parasites. However, there is some question as to the validity of separating the two genera on this basis (see Steinhaus 1949). In *Glugea*, the host cell is greatly hypertrophied, while in *Perezia*, it shows no hypertrophy (Kudo 1924). Since the microsporidian of the imported cabbageworm causes only slight hypertrophy of the host cells, it is presumably closer to *Perezia* than to *Glugea*.

Paillot (1918*a*, *b*, 1924*b*) described in 1918 two species of Microsporidia, *Perezia mesnili* Paillot and *P. legeri* Paillot, from the European cabbageworm, *Pieris brassicae*, and in 1924 a third species, *Perezia pieris* Paillot from the same host.

Perezia legeri usually parasitized the fat tissues and certain giant cells of the blood, but occasionally a general infection occurred in which the spores were found in all the tissues. Paillot (1924*a*, 1933) was unable to transmit this species by feeding the spores to the larvae. This microsporidian had schizonts which formed "chainettes" of two to four cells. Some schizonts had several nuclei, 4 to 11 in number, and generally were large and of varied shapes. The spore had a distinct vacuole near the base of the polar filament.

Perezia mesnili and *P. pieris* differed from *P. legeri* in attacking mainly the Malpighian tubules and the silk glands, but other tissues, such as fat, muscle, and intestinal epithelium, were also parasitized. These two species could cause infection through the digestive tract of the host. They had similar types of spores but without a vacuole such as that in *P. legeri*. The spore of *P. mesnili* was binucleate, while that of *P. pieris* was initially mononucleate and became binucleate when it matured. The polar filaments of both *P. mesnili* and *P. pieris* had not been extruded by any known means, but Paillot (1918*a*) estimated that the polar filament of *P. mesnili* was 18 to 20 microns. Both microspores and macrospores were found in *P. mesnili*. *P. mesnili* formed "chainettes" of four cells but not more than four. It also produced schizonts with 4, 6, and 8 nuclei, which were grouped 2 by 2. Paillot (1924*b*) did not see chains of cells in *P. pieris*. Multinucleate schizonts were also rarely found in this species and the number of nuclei was never observed to exceed four.

According to the characteristics given above, the microsporidian of the imported cabbageworm is quite distinct from *P. legeri* but resembles *P. pieris* and *P. mesnili* in the following ways: (1) it attacks similar types of tissues; (2) it is easily transmitted by feeding; (3) its spore does not have a distinct vacuole as in *P. legeri*. If Paillot was correct in differentiating *P. mesnili* and *P. pieris* by the presence in the former of "chainettes" and schizonts with more than four nuclei, then the microsporidian of *Pieris rapae* would resemble *Perezia mesnili* more closely.

The microsporidian of *Pieris rapae* is here referred to *Perezia mesnili* Paillot, but there are some differences from the description given by Paillot. This microsporidian appeared to be more virulent on *Pieris rapae* than Paillot reported it to be on *Pieris brassicae*, infected larvae of which were frequently able to develop into adults. The spores formed in *Pieris rapae* varied in size but no distinct separation into microspores and macrospores was evident. Although Paillot was unable to force the polar filaments out of the spores, the polar filaments of spores from *Pieris rapae* were easily expelled by the application of pressure. The polar filaments within the spores from *Pieris brassicae* were estimated at about 18 to 20 microns by Paillot, while the extruded polar filaments of the spores from *Pieris rapae* averaged about 54 microns. However, in my opinion, these differences are insufficient for considering the two forms as distinct species.

Summary

In Hawaii, the imported cabbageworm, *Pieris rapae* (L.), is parasitized in the field by a microsporidian, which is referred to *Perezia mesnili* Paillot. This is apparently the first record of this microsporidian outside of France, and is a new host record. The symptoms of the microsporidian infection in the cabbageworm have been described. The microsporidian was highly contagious to the imported cabbageworm in the laboratory. After feeding on the microsporidian spores, the infected cabbageworms usually died in 6 to 18 days, but one larva completed its development and transformed into an adult. This adult had the microsporidian within its tissues. The life cycle of the microsporidian has been described.

Acknowledgments

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LITERATURE CITED

Hall, I. M. 1952. A new species of microsporidia from the fawn-colored lawn moth, *Crambus bonifatellus* (Hulst) (Lepidoptera, Crambidae). J. Parasit., 38:487-491.

Hall, I. M. unpubl. Life cycle of a new species of microsporidia from the imported cabbageworm, *Pieris rapae* Linn. (Lepidoptera, Pieridae).

Kudo, R. 1924. A biologic and taxonomic study of the microsporidia. Illinois Biol. Monogr., 9:1-268.

Paillot, A. 1918*a*. Deux microsporidies nouvelles parasites des chenilles de *Pieris brassicae*. Compt. Rend. Soc. Biol. [France], 81:66-68.

Paillot, A. 1918*b*. *Perezia legeri* nov. sp. microsporidie nouvelle, parasite des chenilles de *Pieris brassicae*. Compt. Rend. Soc. Biol. [France], 81:187-189.

Paillot, A. 1924*a*. Sur la transmission des maladies à microsporidies chez les insectes. Compt. Rend. Soc. Biol. [France], 90:504-506.

Paillot, A. 1924*b*. Sur *Perezia pieris*, microsporidie nouvelle parasite de *Pieris brassicae* L. Compt. Rend. Soc. Biol. [France], 90:1255-1257.

Paillot, A. 1933. L'infection chez les insectes. 535 pp. G. Patissier, Trévoux.

Steinhaus, E. A. 1949. Principles of insect pathology. 757 pp. McGraw-Hill Book Co., Inc., New York.

Steinhaus, E. A., and K. M. Hughes 1949. Two newly described species of microsporidia from the potato tubeworm, *Gnorimoschema operculella* (Zeller) (Lepidoptera, Gelechiidae). J. Parasit., 35:67-75.

Thompson, C. G., and E. A. Steinhaus 1950. Further tests using a polyhedrosis virus to control the alfalfa caterpillar. Hilgardia, 19:411-445.

Artificial Media and the Control of Microorganisms in the Culture of Tephritid Larvae (Diptera:Tephritidae)

By SHIZUKO MAEDA[1], K. S. HAGEN and G. L. FINNEY

DEPARTMENT OF BIOLOGICAL CONTROL, UNIVERSITY OF CALIFORNIA

The results of initial trials using a blended[2] Hubbard squash, *Cucurbita maxima* var., diet for culturing the larvae of the oriental fruit fly, *Dacus dorsalis* Hendel, were very erratic; at times a good yield of mature larvae was obtained, while at other times little or no development occurred. These inconsistent results were probably caused by certain microorganisms invading the food, since no effort was made to sterilize equipment or to protect the medium from airborne contamination.

Experiments using blended squash under aseptic conditions demonstrated that this medium alone was apparently nutritionally deficient Under the same sterile conditions good larval development was obtained when the blended squash was supplemented with certain amounts of dried brewers' yeast. These results suggested that certain microorganisms, perhaps certain airborne yeasts, in controlled amounts, were beneficial but that other yeasts, molds and bacteria were detrimental.

It was considered impractical to carry on a mass-culture program under aseptic conditions, so a search was made for other means of controlling microorganisms.

The first step was to formulate a synthetic diet that would inhibit the growth of undesirable microorganisms without changing the basal nutrients required for good larval development. The basis of this work was a synthetic medium developed by Beck *et al.* (1949) for rearing the larvae of the corn borer, *Pyrausta nubilalis* (Hübner) under aseptic conditions. It was found that in order to adapt this medium to the peculiar requirements of the fruit fly larvae, certain physical and nutritional changes had to be made. In order to learn these requirements, the larvae had to be reared aseptically and fed known nutrients.[3] The optimal concentrations of many of the nutritional factors were determined.

The larvae of the oriental fruit fly, *Dacus dorsalis* Hendel, the melon fly, *D. cucurbitae* Coquillett and the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) were all reared under aseptic conditions on synthetic media. These tephritid larvae were also reared on synthetic media exposed to airborne contaminants.

Materials and Methods.—The materials and methods used will be discussed under the subsequent sub-topics.

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[1]Formerly with the Department of Biological Control, University of California; at present with the U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine, Honolulu, Territory of Hawaii.

[2]A commercial high speed blender designed for home use was employed.

[3]Since dried brewers' yeast was used as the B group vitamin source, individual vitamins other than choline were not varied. The protein source was dried brewers' yeast and casein in some cases.

Separation and Sterilization of Eggs

The eggs of *D. dorsalis* and *C. capitata* were deposited in sections of orange rind which had been sealed to a glass slide with paraffin and placed in the cages with the gravid flies. This technique of obtaining eggs was developed by the earlier workers on the Mediterranean fruit fly when it was present in Florida. The eggs were washed from the rind section into water. Only well separated eggs were pipetted and placed in a 20 milliliter centrifuge tube containing mercuric bichloride solution (1:1000). The tube of eggs was shaken from time to time during a ten minute sterilization period, after which time the eggs were rinsed three times with sterile distilled water. The disinfected eggs were then pipetted onto a piece of thin, white cloth in a sterilized petri dish. Sterile water was added to keep the egg pad moist. The eggs were held for about 24 hours, in which time most of the eggs hatched. The larvae were used within a few hours after hatching.

Preparation of the Artificial Media

The agar agar was placed in a flask with water and brought to a boiling point. The remaining ingredients were added and the mixture boiled for a few minutes. In each test diet, only one factor was varied. The approximate pH of the media was 5.5. Nitrazine paper was used to determine the pH of the media. Five milliliters of medium were placed in 12 x 125 mm. test tubes, which were plugged with cotton and the upper portions of the tubes covered with paper. The tubes were autoclaved at fifteen pounds pressure for fifteen minutes, then slanted and shaken just before the agar set to insure uniform distribution of nutrients in the medium.

Larval Culture

Five larvae, hatched from surface sterilized eggs, were placed on the artificial medium slant by a sterilized dropper. The slant was examined every day. At the end of six days, only the full grown larvae were counted and weighed. The larval response to a medium was calculated in terms of the weights and the per cent of larvae maturing (herein referred to as recovery).

Sterility Test

At the end of the larval growth period, sterility tests of each tube of medium were run. The tests were made by inoculating a loopful of "digested" medium into brewers' fluid thioglycolate medium and tryptone or nutrient broth. No growth of microorganisms in the broth indicated that the larvae developed under aseptic conditions. Contaminated cultures were discarded. Only 1.4 per cent of the culture became contaminated.

Experimental Design

Twenty-one different diets were tested in triplicate. This entire series was again replicated, and the data shown in Tables 2, 3, and 5 represent the averages from both series.

The diet composition shown in Table 1 was used as the control, or standard diet, in these tests. Unless otherwise idicated, only a single ingredient was varied in concentration from that indicated in the standard diet. The results in larval weights and larval recovery shown opposite each ingredient in all the tables are based upon rearing tests where each listed ingredient was in each case used at the listed concentration as a part of a diet which was identical with the standard diet except in the quantity used of that particular ingredient.

Table 1. **Composition of standard diet.**[4]

Substance	Grams per 100 ml. distilled water
Flaked agar agar	1.1
Glucose	4.9
Casein	1.5
Cholesterol	0.175
Wheat germ oil	0.175
Salt mixture (U.S.P.XIII)[5]	0.35
Brewers' yeast	1.75
Choline chloride	0.07

[4]pH 5.5
[5]Nutritional Biochemicals salt mixture No. 2.

Results.—The experiment outlined in Table 2 was conducted at a mean temperature of 80° F., fluctuating from 72° to 87° F. The relative humidity averaged about 62 per cent, with a range of from 40 to 80 per cent.

Table 2. **Effect of various nutrients on *D. dorsalis* larval growth and recovery under aseptic conditions.**

Diet	Varied ingredient in otherwise standard diet	Per cent	Aver. larval wt. in mg.	Aver. % larval recovery
1.	Brewers' yeast	0.0	All died	0.0
2.	Brewers' yeast	2	21.4	76.6
3.	Brewers' yeast	4	19.9	66.7
4.	pH 4.5		21.0	85.0
5.	Cholesterol Wheat germ oil	0.0 0.53	20.8	73.3
6.	Cholesterol	0.35	20.7	85.0
7.	Cholesterol Wheat germ oil	0.35 0.0	21.0	90.0
8.	Standard diet[6]		20.4	88.3

[6]Composition of standard diet shown in Table 1.

The data shown in Table 2 indicate that the 1.75 per cent level of brewers' yeast which was present in the standard diet stimulated the best recovery of *D. dorsalis* of any of the levels of yeast used. When brewers' yeast was omitted entirely from the diet none of the larvae matured. Increasing the concentration of brewers' yeast above 1.75 per cent appeared to be somewhat detrimental to larval recovery. The omission of both cholesterol and wheat germ oil from the diet (not tabulated) resulted in poor growth. The standard amounts of cholesterol and wheat germ oil (1.75 per cent of each), or increasing the cholesterol alone (diet 6), did not produce the degree of recovery produced by the 0.35 per cent level of cholesterol without the wheat germ oil (diet 7).

Since cholesterol is rather expensive for rearing large numbers of larvae, lanolin was tried as a substitute. The larvae reared on diets containing from 0.05 to 0.25 per cent lanolin did not develop normally. Lanolin (hydrous wool fat) is an ester of cholesterol and apparently is not easily hydrolyzed.

Another series of experiments was conducted varying the remaining nutritional factors not treated in the foregoing tests. This series of experiments (Table 3) was carried out at room temperatures fluctuating between 74° to 86° F., and the relative humidity varied from 46 to 80 per cent. The mean temperature and humidity were 80°F. and 63.5 per cent, respectively.

Table 3.—**Effect of various nutrients on *D. dorsalis* larval growth and recovery under aseptic conditions.**

Diet	Varied ingredients in otherwise standard diet	Per cent	Aver. larval wt. in mg.	Aver. % larval recovery
1.	Glucose	2	21.7	36.6
2.	Glucose	6	20.3	56.6
3.	Sucrose Glucose	2 0	20.7	63.3
4.	Sucrose Glucose	4 0	21.7	100.0
5.	Salt Mixture (U.S.P. XIII)	0	18.7	66.6
6.	Salt mixture (U.S.P. XIII)	0.6	19.8	73.3
7.	Choline chloride	0	18.4	76.6
8.	Choline chloride	0.2	20.5	66.6
9.	Peptone Casein	2 0	21.7	13.3
10.	Casein	0	20.5	49.8
11.	Casein Brewers' yeast	0 3.25	20.0	80.0
12.	Casein	3	20.5	60.0
13.	Standard diet[7]		19.9	80.0

[7]Standard diet formula shown in Table 1.

The data shown in Table 3 indicate the best levels for the following: sucrose 4.0 per cent; salt mixture 0.35 per cent; choline chloride 0.07 per cent; brewers' yeast 3.25 per cent.

The diet containing 2.0 per cent sucrose apparently did not furnish sufficient carbohydrate as indicated by the excellent larval recovery from a 4.0 per cent sucrose diet. The best larval recovery from a glucose source was obtained at a concentration of 4.9 per cent (standard diet). The larval recovery from the 2.0 per cent sucrose diet (diet 3) was nearly double that of the 2.0 per cent glucose diet (diet 1). This possibly indicates that the fructose molecule of sucrose is an important factor. This is shown also when comparing the glucose control diet to the 4.0 per cent sucrose diet. However, under insectary conditions where aseptic techniques were not exercised, it was found that 4.9 per cent glucose concentration gave better results than did the 4.0 per cent sucrose concentration. It appears that using sucrose under these conditions permits vigorous and detrimental fermentation.

Of the salt concentrations used, the control diet, which contained 0.35 per cent salt mixture, stimulated the best larval development, while increasing the salt content to 0.6 per cent, or omitting it altogether was inferior. However, the diet was not entirely devoid of salts in the latter diet for brewers' yeast contains minerals.

The most effective concentration of choline chloride was found to be 0.07 per cent. Although the diets were not supplemented with choline, a sufficient amount was present, evidently being provided through the use of brewers' yeast. A diet containing 3.25 per cent brewers' yeast and no casein (diet 11) stimulated nearly the same degree of larval recovery as did the control diet (diet 13) which contained 1.5 per cent casein and 1.75 per cent dried brewers' yeast. Nearly half the weight of brewers' yeast is protein. Consequently, increasing the yeast concentration in a diet compensated for the omission of casein as a protein source. A diet without casein and containing only 1.75 per cent brewers' yeast only gave 50 per cent larval recovery. Increasing the concentration of casein to the 3.0 per cent level was detrimental to larval development. The use of peptone as a source of protein supported good growth but permitted poor larval survival.

A new, improved diet was formulated, and was the product of the foregoing experiments in that the proved levels of each ingredient were used. The formula of the improved diet is shown in Table 4.

Table 4.—**Composition of an improved purified diet for rearing *D. dorsalis* larvae under aseptic conditions.**

Substance	Grams per 100 ml. distilled water
Flaked agar agar	1.1
Sucrose	4.0
Cholesterol	0.35
Salt mixture (U.S.P. XIII)	0.35
Brewers' yeast	3.25
Choline chloride	0.07

The results obtained from comparing the improved diet (Table 4) with that of the original standard diet (Table 1) are shown in Table 5. Also, two other media having the same composition as the standard diet but differing only in pH were tested. These data are also shown in Table 5. The above experiment was subject to room temperatures fluctuating between 74° to 85°F., and the humidities varied from 48 to 80 per cent. The mean temperatures and humidities were 80.5 and 62 per cent respectively.

Table 5.—**Effect of different pH reactions and the new, improved diet upon the development of *D. dorsalis* larvae, aseptically reared.**

Diet	pH	Aver. larval wt. in mg.	Aver. % larval recovery
Improved[8] with pH	5.5	24.34	100.0
Standard[9] with pH	5.5	23.32	96.6
Standard with pH	7.0	23.1	90.0
Standard with pH	8.0	23.0	96.6

[8]Composition of Improved diet shown in Table 4.
[9]Composition of Standard diet shown in Table 1.

The data shown in Table 5 indicate that the improved diet stimulated better larval growth and recovery than was obtained from the standard diet, although the differences are so small as to suggest need for further testing.

The *D. dorsalis* larvae apparently can tolerate a wide range of acidity and alkalinity under aseptic conditions, for it has been shown that they developed equally well in media of pH 4.5, 5.5, 7.0 and 8.0. However under insectary conditions where aseptic techniques were not followed any media with a pH higher than 5.5 permitted poor larval growth as a result of heavy bacterial contamination. Thus it was possible to mass-culture the larvae under normal laboratory conditions in the presence of bacteria by adjusting the acid reaction to pH 4.5.

Larval Population Density supported by an Artificial Medium

The following experiment was designed to determine the number of *D. dorsalis* larvae that one gram of synthetic medium would support. The medium employed was the improved diet shown in Table 4. Five milliliters of this medium were placed in test tubes and slanted. The eggs were sterilized as already described. Triplicate tubes were used for each larval density tested. The results obtained are shown in Table 6.

Table 6.—**Population density of aseptically reared *D. dorsalis* larvae supported by one gram of artificial medium.**[10]

No. of larvae per gram of medium[10]	Larvae per tube	Aver. No. of larvae recovered	Per cent recovery	Aver. wt. of mature larva in mg.
3	15	13	86.6	17.9
4	20	17	85.0	16.7
5	25	23	92.0	16.6
6	30	24	81.6	14.6
7	35	32	91.4	14.5
8	40	32	80.0	15.0
9	45	41	92.2	13.9
10	50	44	88.0	12.4

[10]Composition of medium shown in Table 4.

The data shown in Table 6 show that as the number of larvae per gram of medium increased the larval weight decreased. The number of larvae maturing remained fairly constant. The optimal range appears to be between three to eight larvae per gram of medium. Apparently one gram of medium can actually support more than ten larvae, but the exact number was not determined.

Rearing *D. dorsalis* Larvae in synthetic Media exposed to airborne Contaminants

Since it was impractical to mass-culture the tephritid larvae under aseptic conditions, various artificial media were tested, utilizing facts which were learned from the experiments with aseptic media. Marucci and Clancy (1950) found that the agar base medium known as the Texas *Drosophila* formula and a yeast-agar-water medium supported larval development of *D. dorsalis, D. cucurbitae* and *C. capitata.* The control of detrimental microorganisms was apparently obtained by relying on larval density. The density found necessary to prevent a surface scum was from 50 to 100 larvae per Petri dish.

Since it was rather difficult to depend on a definite number of larvae hatching, because of some variability in egg fertility, it was necessary to develop a medium that would support a wide variation of larval population densities. The only limit necessary to observe would be that of overpopulating a tray of medium, which would result in smaller sized flies. Consequently, a medium was desired that would support a lower density than the actual medium potential in the event of poor egg hatch and in spite of being exposed to microorganisms.

The formula of the purified medium adopted for mass-culturing *D. dorsalis* larvae exposed to potential airborne contamination is shown in Table 7.

Table 7.—**Composition of a purified diet utilized in the mass-culture of *D. dorsalis* larvae in the presence of microorganisms.**

Substance	Grams per 100 ml. of water
Agar	1.3
"Butoben"[11]	0.12
Glucose	4.9
Wheat germ oil	0.175
Cholesterol	0.175
Salt mixture (U.S.P. XIII)	0.35
Brewers' yeast	3.0
Choline chloride	0.07

[11]N-butylparahydroxybenzoate—Merck.

The preparation of the medium outlined in Table 7 involved boiling the mixture for several minutes to dissolve or suspend the ingredients, allowing it to cool and adjusting the reaction to approximately pH 4.5 with 0.1 N hydrochloric acid. After the agar had set, the medium was blended in a high speed blender to obtain a pulpy consistency. The medium was stored in a refrigerator and used when needed.

The cost of this synthetic medium for mass-culture of *D. dorsalis* was nearly prohibitive even though an average of 5000 mature larvae were obtained, in eight days, from 7000 eggs placed in 800 milliliters of medium. However, the knowledge gained from developing the above diets made possible the final practical medium. This proved to be a blended vegetable medium which supplied the bulk of the expensive nutritive factors, lipids primarily, fortified with certain nutrients that were lacking. Brewers' yeast was used to provide the deficient nutritional factors. Since agar was not used, the preparation of the medium was simplified. From the foregoing results and those of previous workers dealing with other insects, it was found that "Butoben" would inhibit the molds and yeasts. The bacterial growth was controlled by altering the pH to 4.5 by adding a certain amount of hydrochloric acid.

Larval Culture of *Ceratitis capitata*

The standard synthetic medium (Table 1) was used for culturing *C. capitata* larvae under aseptic conditions using proved methods and techniques as in *D. dorsalis* experiments. In the following experiment only the level of the brewers' yeast was varied. A pumpkin medium supplemented with two per cent dried brewers' yeast was also tested. The various yeast concentrations tested and the results obtained are shown in Table 8.

Table 8.—**Effect of different brewers' yeast concentrations in various artificial media upon the larval development of *C. capitata* under aseptic conditions.**

Medium	Per cent brewers' yeast	Aver. larval wt. in mg.	Aver. % larval recovery
Standard[12]	1.75	14.53	86.6
Standard	2.0	12.66	80.0
Standard	4.0	13.85	46.6
Pumpkin[13]	2.0	13.3	66.6

[12]Composition of standard medium shown in Table 1.
[13]Pumpkin pulp was blended. A variety of *Cucurbita pepo* was used.

The data shown in Table 8 indicate that 1.75 per cent brewers' yeast level in a synthetic medium permitted growth of larger larvae and a greater number to mature.

Larval Culture of *Dacus cucurbitae*

A single experiment was conducted to determine whether the melon fly larvae would develop in a synthetic medium under aseptic conditions. Blended pumpkin, *C. pepo* var., and the standard purified medium (Table 1) were tested. The same techniques and methods were used as in the previous experiments.

The larval development was better in the standard medium than that obtained from the blended pumpkin medium supplemented with yeast. The larval growth was variable when melon fly larvae were reared in the pumpkin medium, as indicated by the number of undeveloped larvae which resulted. However, in the artificial medium (Table 1), the larval development was good and the sizes of the larvae were more uniform.

Summary

A method was found whereby *Dacus dorsalis, D. cucurbitae* and *Ceratitis capitata* larvae could be reared in synthetic media under aseptic conditions. Major nutritional factors were varied to ascertain "optimal" levels of each factor. The synthetic diets led to the development of an economical artificial medium[14] which was used in the mass-culture of three species of fruit fly larvae without requiring expensive aseptic techniques or the use of purified diets.

LITERATURE CITED

Beck, S. D., J. H. Lilly and **J. F. Stauffer.**
1949. Nutrition of the European corn borer, *Pyrausta nubilalis* (Hbn.) I. Development of a satisfactory purified diet for larval growth. Ann. Ent. Soc. Amer. 42(4):483-496.

Marucci, P. E. and **D. W. Clancy.**
1950. The artificial culture of fruit flies and their parasites. Proc. Hawaiian Ent. Soc. 14(1):163-166.

[14]This medium will be described in a future paper by G. L. Finney.

The Elimination of Subterranean Termite Damage by Structural Methods

By CHESTER B. KECK[1]

The author estimates that the subterranean termite (*Coptotermes formosanus* Shiraki) under ordinary conditions does 95 per cent of all termite damage in Hawaii. To control this termite should therefore eliminate 95 per cent of the termite damage. Authorities agree that the answer to the elimination of subterranean termite damage is structural practices. Dr. Thomas E. Snyder[2] in the second edition of his book "Our Enemy the Termite," page 163 states, "Proper construction is the answer to the termite problem," and on page 164 lists the most resistant type of construction as, "Houses the foundations or basements of which are entirely concrete, including baseboards, with cove or 'sanitary arc.'" In "How to Recognize and Control Termites in Illinois" B. C. Berger[3] in discussing structural methods to eliminate termite damage says, "All wood in the structure should be isolated so that termites cannot gain access to it without building shelter tubes in exposed places where they may be readily detected and the termites quickly destroyed by supplementary control measures."

The following three steps should eliminate damage by the subterranean termite if followed in future construction or applied to existing structures:

1. No wood in, or in contact with, the soil. This will eliminate any future colonies from becoming established. (See Figure 1.)

2. Several inches of concrete between soil or concrete floor at foundation level and wood of structure above. This should be designed in such a way as to force the termites to build a shelter tube between soil or concrete floor and wood where it can be seen by simple inspection (see Figures 2 and 3.)

3. Inspect periodically for shelter tubes and treat if found. (See Figure 4.) Treatment is made by inserting a small amount of insecticide dust into shelter tubes.

It is well to understand the essential points in the life history and habits of the termite upon which these three steps are based. The subterranean termite requires cellulose, which it usually obtains from wood, and moisture, which it obtains from the ground, in order to survive. The cellulose is broken down by microscopic organisms in the termites' alimentary tract into food elements which the termite can assimilate. The most essential use for the moisture is to raise the moisture content of the

[1]Entomologist, Fourteenth Naval District Public Works.

[2]Snyder, T. E. Our Enemy the Termite. Second Edition. Comstock Publishing Co., Ithaca. N. Y. 1948.

[3]Berger, B. G. How to Recognize and Control Termites in Illinois. Cir. 41 Nat. Hist. Sur. Urbana, Ill. 1947.

air in the termite nest and all its galleries so as to maintain a relative humidity of 90 per cent. In order to maintain proper moisture content in the tunnels of the wood where the termites are feeding, they will build shelter tubes of soil, chewed up wood, pellets of excrement, etc., over impervious material, such as rich concrete, or unpalatable material, such as resistant wood, between the soil where they obtain moisture and the wood they are feeding in.

Being social insects, termites have different castes specialized to carry on the different functions of the colony. The original queen, as well as alternate queens, produce all the eggs, males fertilize the queens, soldiers guard the colony against attack by enemies, and workers (and immature nymphs) do all the work for the colony. Soldiers and workers are potential, but sterile males and females, therefore, they never reproduce.

There are two types of reproduction among social insects; namely, the reproduction of the individuals of the colony and the reproduction of the colony itself. It is well to realize that it is the colony that we want to eliminate or control. In order to reproduce the colony, there is a season of the year when winged males and females are produced by the hundreds or thousands. Each pair (male and female) may start a new colony if the right environment is found. However, natural mortality is so high that only about one pair in 1,000 ever succeeds in starting a nest which results in a colony. The winged males and females fly for about 10 minutes; then the wings break off and the females (followed by a male) search for a suitable place to start a nest. The subterranean termite male and female must find cellulose (usually wood) and moisture in exactly the same spot or it will be impossible for them to start a nest. This is because the original pair must care for their young (only about 20) for the first year and cannot build a shelter tube for even a short distance to obtain moisture. It is estimated that it takes from 4 to 10 years for the progeny of an original pair to build up to where the colony will do appreciable damage to a building. Where damage occurs sooner than that in a new structure, it is because there is a termite colony already established in the vicinity.

Our first preventive measure, **no wood in, or in contact with, the soil,** is based on the fact that the original male and female swarming pair cannot establish a nest without cellulose (wood) and moisture in exactly the same spot. Therefore, stumps and large roots should be removed from the building site. No wood should be allowed to be buried in back fills. All grade stakes, form boards, wood blocks under plumbing in the soil should be removed as the building progresses. Porch steps, lattice work, built-on structures such as garages, water heater shelters, etc., should be watched for wood in contact with the soil. In the areas surrounding a building **no wood in, or in contact with, the soil** is also essential since termites will tunnel for long distances to obtain food. Parking bumpers, fence posts, and flower bed borders should be made of metal or concrete or have any wood well up off the ground.

Step 1 alone should eliminate termites in time, but because of man's shortcomings or carelessness and to aid in carrying out step 1, step 2 must be followed.

Step 2 is: **Several inches of concrete between soil or concrete floor at foundation level and wood of structure above.** This will force any termite colony present in the soil, or which may develop in the soil later, to build a shelter tube up over the concrete in the open where it can be seen. In carrying out step (2) there are two types of buildings to consider as illustrated in drawings, Figures 2 and 3.

a. Figure 2 shows the type of building where the floor is up off the ground and since subterranean termite control must be carried out at the ground level, we go beneath the floor to get proper construction to eliminate termites in this type of structure. The first requirement is to make

FIGURE 1

This shows where form boards were removed except where they "wouldn't show" under porch. Where form boards were in contact with soil, a large colony of subterranean termites developed and did several thousands of dollars damage to the building.

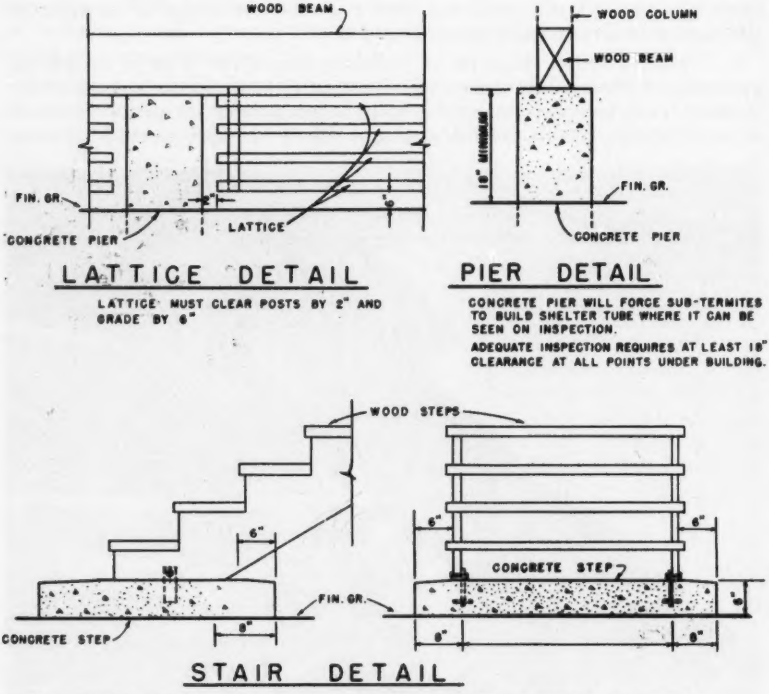
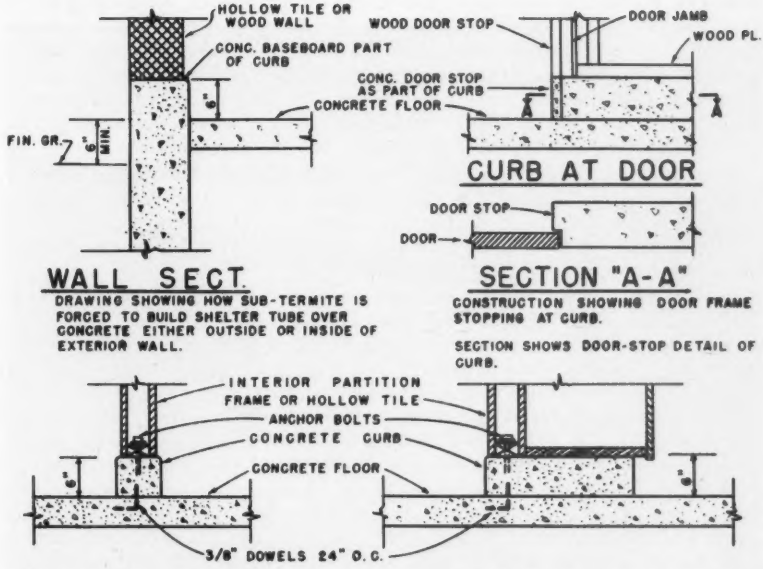


FIGURE 2

This drawing shows type of building where floor is above ground. Note how termites may not attack wood without building shelter tube (as shown in Figure 4) from soil up over concrete. In this type of structure all necessary precautions against termite damage are taken below the floor. Proper construction below the floor saves all money for termite shields, and for resistant or treated lumber above floor.


HOLLOW TILE OR WOOD WALL
CONC. BASEBOARD PART OF CURB
CONCRETE FLOOR
FIN. GR.
6" MIN.
WOOD DOOR STOP
DOOR JAMB
WOOD PL.
CONC. DOOR STOP AS PART OF CURB
CURB AT DOOR
DOOR STOP
DOOR
WALL SECT.
DRAWING SHOWING HOW SUB-TERMITE IS FORCED TO BUILD SHELTER TUBE OVER CONCRETE EITHER OUTSIDE OR INSIDE OF EXTERIOR WALL.
SECTION "A-A"
CONSTRUCTION SHOWING DOOR FRAME STOPPING AT CURB.
SECTION SHOWS DOOR-STOP DETAIL OF CURB.
INTERIOR PARTITION FRAME OR HOLLOW TILE
ANCHOR BOLTS
CONCRETE CURB
CONCRETE FLOOR
3/8" DOWELS 24" O.C.
INT. WALL SECT.
PARTITION SHOWING HOW SUB-TERMITE IS FORCED TO BUILD EXPOSED SHELTER TUBE OVER CONCRETE CURB TO GET TO WOOD IN PARTITION.
BUILT-IN CABINETS
BUILT-IN CABINET CONSTRUCTION FORCING SUB-TERMITE TO BUILD EXPOSED SHELTER TUBE OVER CONCRETE TO GET TO WOOD IN CABINET.

STANDARDS FOR TERMITE PROTECTION

FIGURE 3

This drawing shows type of structure where concrete floor rests on soil. Termite resistant principles must be taken above floor to isolate wood from expansion joints or cracks in floor which would provide termites with a hidden entrance. In this type of structure expense for resistant or treated wood can also be saved.

sure the building is well up off the ground at all points so as to make inspection (Step 3) readily possible. There should be a clearance of 24 inches with no point or clearance less than 18 inches. There should be several inches of rich concrete between the soil and any weight-bearing timbers, including steps or other built on structures, extending above any possible future grade. Hollow tile should have rich concrete between it and any soil since termites can usually find a crack in the mortar between tiles, and the hollow gives them an ideal hidden entrance. Filling the void in hollow tile with mortar for a few courses is not sufficient. It is sufficient to cap the top of hollow tile below any wood with several inches of reinforced concrete as is done in some construction.

Such a concrete binder which extends only beneath a window, however, does not protect against termites entering the window through hollow tile at the sides or tops, if the tile reaches the soil. Wood lattice work should clear the soil by several inches and not nullify proper construction at steps or porches.

b. Figure 3 shows the second and only other type of structure in the prevention of subterranean termite damage. This is where we have a concrete slab or floor resting on the ground. With this type of structure, in order to comply with step 2, we must have our several inches of concrete above the floor to force the termites to build shelter tubes where they can be readily seen and treated. Principles for this type of construction are shown in Figure 3. This type of construction usually has a curb wall around the outside; but on the inside, baseboards, door frames, partitions, cabinets, stairs, etc., rest on the floor giving termites a hidden entrance from expansion joints, cracks in the floor, etc., to wood. Outside curb walls should form a part of the door frame as shown in Figure 3; and partitions, bottom stair steps, and cabinets should be up on concrete curbs.

It is relatively easy to understand the critical points to watch to force subterranean termites to construct their shelter tubes where they can be seen in the building type where the floor is well up off the ground (Figure 2). Concrete or air space between the soil and any wood of the structure and sufficient elevation to give crawl space for inspection and possible treatment of shelter tubes are the main things to watch. Elevation at the highest grade point is perhaps the most often violated. Allowance must be made for future grades or fills.

The critical points to watch in the type of structure where the floor is a concrete slab resting on the ground (Figure 3) may take a little more care. These are the base boards of all side walls, partitions and cabinets with especial emphasis at the door frame bases. All curbs should form a part of the base of the door frame. The base of the door frame is the principle most often violated. Many buildings have curbs under side walls and partitions but the curb is carefully stopped to permit the door frame to go down to the expansion joint between the side wall curb and concrete floor. The door frame then provides the termites with a hidden entrance to the structure above. There are many instances where if the concrete curb had formed a part of the door frame thousands of dollars from subterranean termite damage would have been saved.

c. Step 3 is simple – **look for shelter tubes and if found treat them by breaking tube and inserting Paris Green dust, DDT dust 50%, Chlordane dust or any other of many suitable insecticide dusts.** The frequency of inspection should be determined by the presence of termites in the area, but should not be less than once each year.

FIGURE 4

This shows how concrete construction forced termites to build an earthen shelter tube in the open in order to reach wood in the structure above. Note how termite shield did not prevent termites from reaching wood and, therefore, gives a false sense of security. With concrete between soil and wood of structure a simple inspection will reassure owner that no termite damage exists even several stories up in structure if no shelter tube is found.

Original cost of termite resistant structures cheaper.

"Cheaper in the long run" is easy to believe, but to say the original cost is cheaper may require some explanation. If this type of construction is followed, the cost for metal termite shields and resistant or treated lumber in the structure can be saved. Also by forming a baseboard as a part of all outside concrete wall curbs and partitions, finish-lumber can be saved. Money can also be saved by omitting any soil treatment prior to building since, if properly constructed, shelter tubes will have to be constructed in the open where simple treatment will eliminate them.

The Genus Glaucytes in the Pacific (Coleoptera: Cerambycidae)

By J. LINSLEY GRESSITT

PACIFIC SCIENCE BOARD, NATIONAL RESEARCH COUNCIL*[1]

The genus *Glaucytes* belongs to the subfamily Cerambycinae, though the species somewhat resemble members of the tribe Tmesisternini of the subfamily Lamiinae. The genus has a discontinuous distribution involving Madagascar, Mauritius, Bourbon, Ceylon, the Moluccas, Melanesia, Queensland and western Polynesia. This distribution is not as erratic as it might appear, as there are a number of cases where a genus may be restricted to the Malagasy Subregion and the southwestern Pacific area. Furthermore, the fauna of northern Queensland is known to be more closely related to that of New Guinea than to the rest of Australia as a whole, and of course Melanesia is the primary source of the fauna of west central Polynesia. As to Ceylon, elements of its fauna are known to be related to that of Madagascar, but not all the groups primarily occurring in Madagascar and the south Pacific are known from Ceylon. The tribe Glaucytini includes, besides *Glaucytes,* three genera restricted to Madagascar and two to Indonesia or to Indonesia together with southeastern Asia. The Indonesian genus, *Cleonice,* is represented on Morotai by *C. vestita* Thomson which is similar in size and shape to species of *Glaucytes,* but is entirely clothed above with satiny, golden buff pubescence with variable oblique darker bands changing with the angle of light reflection. Specimens of *C. vestita* were collected on Morotai in September, 1944 by P. J. Darlington (in the Museum of Comparative Zoology, Cambridge, Mass.) and March, 1945 by Gilbert Banner (in the American Museum of Natural History, New York City). I am indebted to Dr. R. H. Arnett, Dr. M. A. Cazier, Dr. E. A. Chapin, Dr. P. J. Darlington, Mr. Hugh B. Leech, Dr. J. A. G. Rehn, Dr. E. S. Ross and Miss Amy Suehiro for kindly providing material for study.

The generotype of *Glaucytes* is *Cerambyx scriptus* Fabricius, which is a synonym of *Cerambyx interruptus* Olivier (Mauritius). The species of the genus may be recognized by having the eye prominent and finely facetted, the middle coxal cavity closed to the epimeron by the episternum, the tarsal claws widely divergent and the dorsum generally with markings of metallic pubescence in depressed areas.

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* Address: Bernice P. Bishop Museum, Honolulu.

[1] While this paper was in press, Dr. Gressitt wrote from the Palaus that he had obtained a new species of *Glaucytes* on Babelthuap.

Key to the Pacific species of Glaucytes
(except *vittifera* Buquet)

1. Elytra with at least some discal spots or transversely oblique bands 2
   Elytra without any spots or transverse bands, each with a submedian stripe of close yellowish pubescence from base to beyond middle, and a narrow posterior stripe along suture; a similar stripe along each side of head and prothorax, and another broader one along each side of hind thorax and abdomen; body metallic green to reddish brown with a greenish tinge (New Hebrides) ..... **helenae** (White)

2. Each elytron with a discal stripe along basal two-fifths, besides two or three discal spots and sutural stripe 3
   Each elytron with two to five transverse or oblique bands or spots, but without a longitudinal discal stripe on basal portion 6

3. Pubescence golden, or partly white; no distinct oblique pubescent band behind humerus; metepisternum largely pubescent; femora partly red 4
   Pubescence silvery with a greenish golden tinge; a distinct oblique pubescent band behind humerus; metepisternum largely glabrous posteriorly; body black with a slight purplish tinge; femora black (Solomon Is.) ..... **graphica** (Boisduval)

4. Body largely reddish brown to pitchy; femora largely reddish; basal stripe of each elytron narrowed in middle; elytra only partly regularly punctured basally; pubescence golden 5
   Body black; femora reddish basally; basal stripe of each elytron widened in middle; elytra regularly punctured on basal halves; prothoracic pubescence whitish (Santa Cruz Is.) ..... **santaecrucis** Heller

5. Glabrous portion of each side of prothorax largely impunctate; punctures on basal portions of elytral discs mostly less than one-third as wide as spaces between them (New Hebrides) ..... **notabilis** n. sp.
   Glabrous portion of each side of prothorax deeply and distinctly punctured; punctures on basal portions of elytral discs mostly at least one-half as wide as spaces between them (Fiji) ..... **muiri** Gressitt

6. Elytra truncate apically with each angle toothed; each elytron with five spots or bands 7
   Elytra rounded apically; each elytron with only two bands, the first transverse and the second oblique; shiny black; prothorax impunctate with whitish pubescence at sides and base (New Caledonia; Lifu) ..... **albocincta** (Chevrolat)

7. Pronotum distinctly punctured, particularly on glabrous area on each side of disc; posthumeral band of each elytral disc divided into two spots, or nearly so divided 8
   Pronotum impunctate, at least on glabrous areas; posthumeral band of each elytron not divided into two spots 9

8. Dorsum finely punctured; punctures much smaller than spaces between them, particularly sparse along median line of pronotum; elytral apices obliquely truncate; posthumeral elytral band not distinctly divided into two separate spots (Samoa) ..... **aureosignata** Aurivillius
   Dorsum grossly punctured; punctures of elytra mostly about as large as spaces between them, those of median line of pronotum larger than interspaces; elytral apices strongly sinuate; posthumeral elytral band divided into two separate spots (Queensland) ..... **suturalis** Pascoe

9. Each elytron with five bands including basal and apical bands, each free from suture except for first and last; prothoracic pubescence even except for the limited glabrous areas (northern New Guinea) ..... **quadrifasciata** Gressitt
   Each elytron with four bands including apical spot, first and third small, second reaching to suture; prothoracic pubescence denser posteriorly (Batchian) ..... **scitula** Pascoe

Glaucytes helenae (White), 1855, Cat. Col. Brit. Mus. 8:342, pl. 8, fig. 8. One specimen (Bishop Mus.) was taken at Port Vila, Efate, New Hebrides, December 4, 1923 by W. H. Ford. Known only from New Hebrides, and differently marked from the other Pacific species of the genus.

Glaucytes graphica (Boisduval), Fig. 1. 1835, Voy. Astrolabe Ins. 2:511, pl. 9, fig. 17.

Numerous specimens (U. S. Nat. Mus.) were taken in the Munda Pt. area, New Georgia, Solomon Is., January-February and June, 1944 by J. G. Franclemont, and on Bougainville, Solomon Is., June, 1944 by A. B. Gurney; two (Mus. Comp. Zool.) Guadalcanal, Solomons, 1944, L. N. Jarcho; one (Bishop Mus.) Guadalcanal, January, 1921, J. A. Kusche; one (Amer. Mus. Nat. Hist.) Guadalcanal, July 23, 1945, Frank Cillev; one (Cal. Acad. Sci.) Tenaru River, Guadalcanal, January, 1945, G. E. Bohart. Heller (1935, Arb. Morph. Tax. Ent. Berlin 2:267) states that although in the original description *graphica* was reported from Vanikoro and in the Coleopterorum Catalogus (39:438) from New Hebrides, probably both are wrong and the species is restricted to the Solomon Islands. Heller reported this species from Tulagi.

Glaucytes santaecrucis Heller, 1935, Arb. Morph. Tax. Ent. Berlin 2:267. Known only from Vanikoro, Santa Cruz Islands.

Glaucytes notabilis Gressitt, new species. Fig. 2.

Female: Reddish brown to pitchy or nearly black, clothed in part above with rich golden pubescence and beneath with silvery white to yellowish pubescence: head reddish, pitchy above, clothed with golden except for a narrow triangle on occiput and another on frons, with goldish silvery pubescence at side and on clypeus; antenna reddish on scape, black on remainder, with moderate oblique internal hairs on second to sixth segments; prothorax pitchy above, reddish beneath, with four distinct golden stripes on disc, each narrower than an interspace, and barely joined along basal margin,

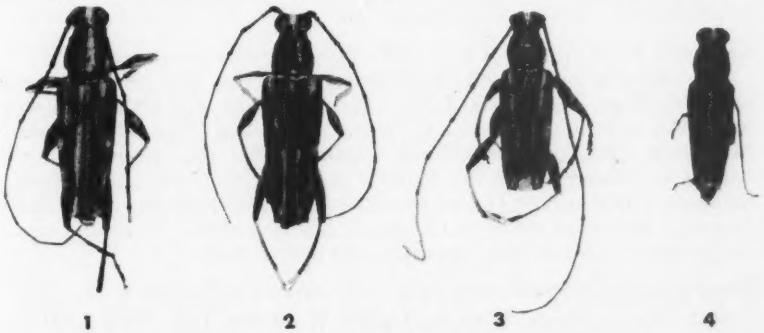

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Fig. 1. **Glaucytes graphica** (Boisduval); New Georgia, Solomon Is.
Fig. 2. **Glaucytes notabilis** Gressitt, n. sp.; holotype, New Hebrides.
Fig. 3. **Glaucytes muiri** Gressitt; Ovalau, Fiji.
Fig. 4. **Glaucytes quadrifasciata** Gressitt; Astrolabe Bay, New Guinea.

with silvery pubescence on sternum; scutellum blackish, subglabrous; each elytron dark reddish castaneous with a slight bronzy tinge, marked on depressed areas with pubescences as follows: (1) a golden stripe from base near humerus to end of basal two-fifths somewhat closer to suture, (2) a narrow short silvery and golden stripe along suture just behind scutellum, (3) some thinner pale pubescence below and just behind humerus, (4) a golden sutural stripe from middle to apex, broadest at anterior end, slightly narrower near apex, and narrower and silvery in between and at extreme apex, (5) an oblique transverse spot at middle of disc, and (6) a longitudinal spot between it and apex; ventral surfaces reddish, largely clothed with silvery pubescence, which is closer and slightly golden at sides; legs with femora largely red, their apices and tibiae and tarsi black; tarsi clothed with pale hairs, much denser and whiter on hind tarsus.

Head distinctly narrower than prothorax, obtusely concave between antennal supports, moderately and irregularly punctured, sparsely so on genae. Antenna slender, barely one-fourth again as long as body; scape compressed, irregularly, in part finely, punctured; third and fifth segments subequal in length, each nearly one-half again as long as fourth; following decreasing in length. Prothorax slightly broader than long, broadest behind middle, distinctly constricted near apex and slightly so near base, feebly and irregularly punctured, sparsely so on middle of disc and glabrous portion of side; disc with a narrow raised line across middle, and some feeble wrinkles between it and base. Scutellum declivous, trapeziform, nearly impunctate. Elytra narrowed posteriorly, each emarginate-truncate apically with both sutural and external angles sharply projecting; disc finely and sparsely, and in large part irregularly, punctured, the punctures mostly about one-fourth as wide as spaces between them, and still smaller posteriorly. Ventral surfaces finely and irregularly punctured; femora finely and sparsely punctured. Length 12.7 mm.; breadth 3.7 mm.

Holotype, female (Calif. Acad. Sci.), Espiritu Santo Island, New Hebrides Islands, December 23, 1948, W. Bauer collector.

Differs from *G. muiri* Gressitt, to which it is almost subspecifically related, in having the prothorax more finely punctured, and much more sparsely so at sides of disc, the elytra much more finely, and less regularly punctured, the sutural angle more produced and the median discal spot narrower and more transverse. It differs from *G. santaecrucis* Heller in being largely reddish brown instead of black, in having the elytral punctures less regular and the basal discal stripe narrowed instead of broadened in middle, and in having the prothoracic pubescence golden instead of whitish.

Glaucytes muiri Gressitt, Fig. 3. 1940, Proc. Hawaiian Ent. Soc. 10:417.

One (Mus. Comp. Zool.) Nadarivatu, Viti Levu, Fiji, W. M. Mann; one (Fiji Dept. Agric.) Viti Levu. Type in Bishop Mus. Others (Bishop Mus.) Viti Levu and Ovalau, recorded by Dillon and Dillon (1952, Bishop Mus. Bull. 206:35). The Dillons' statement that this species may not belong to *Glaucytes* on the basis of a vague character (pedunculate femora), is misleading. It may be necessary to subdivide the genus *Glaucytes* at a later date, but *muiri* is part of an *"Artenkreis"* including *suturalis, graphica, santaecrucis, notabilis,* and *aureosignata.*

Glaucytes aureosignata Aurivillius, 1928, Insects of Samoa, 4, (2) :140.

One (Bishop Mus.) Afiamalu, Upolu, W. Samoa, July, 1940, 2,200 feet altitude, reared from larva under dead bark, E. C. Zimmerman; others (Bishop Mus.) Tapatapao, Upolu, July 13 and 23, 1940, alt. 800-1,000 feet, from dead logs or beating dead branches, E. C. Zimmerman. Known only from Upolu.

Glaucytes suturalis Pascoe, 1867, Jl. Linn. Soc. Lond., Zool. 9:308.

Two (Bishop Mus.) Cairns, North Queensland, J. F. Illingworth. Known only from Cape York, northeastern Australia.

Glaucytes quadrifasciata Gressitt, Fig. 4. 1951, Ann. Ent. Soc. Amer. 44: 210, fig. 5.

One (Cal. Acad. Sci.) Hollandia, December, 1944, L. W. Saylor; one (U. S. Nat. Mus.) Toem, northwestern New Guinea, March-April, 1945, D. B. Vogtman; three (U.S.N.M.) Finschhafen, eastern New Guinea, May, 1944-March, 1945, B. H. Wilford; one (Phila. Acad. Sci.) Astrolabe Bay, Rhode. Known only from the northern coast of New Guinea.

Glaucytes scitula Pascoe, 1860, Ann. Mag. Nat. Hist. (3) 5:120.

Described from Batchian Island in the Moluccas.

Glaucytes albocincta (Chevrolat), 1858, Rev. Mag. Zool. (2) 10:82 (*ballardi* Montrouzier).

This species is known from New Caledonia (*albocincta*) and Art and Lifu (*ballardi*). Montrouzier recorded it from *Tetracera euryandra*.

Glaucytes vittifera (Buquet), 1844, in Guerin, Icon. Regne Anim. Ins.: 250.

Described from New Holland (Australia).

Competition Among Parasites of the Oriental Fruit Fly[1]

By ROBERT VAN DEN BOSCH[2] and FRANK H. HARAMOTO[3]

UNIVERSITY OF HAWAII, COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION, HONOLULU, HAWAII

The successive rise to predominance by three of the most successful parasites of the oriental fruit fly, *Dacus dorsalis* Hendel, in Hawaii has been an interesting development in the biological control of this pest. The first species to gain prominence was *Opius longicaudatus* (Ashmead), a parasite of second and third instar fruit fly larvae, which increased in abundance rapidly after its initial release and establishment in the summer of 1948. It quickly spread throughout the Islands and remained extremely abundant for about one year. *Opius vandenboschi* Fullaway, which attacks early first instar fruit fly larvae, then replaced *O. longicaudatus* in prominence. *O. vandenboschi* was first liberated at about the same time as *O. longicaudatus,* however, it was relatively scarce until the fall of 1949 when it became exceedingly abundant. It continued to be the most abundant parasite until the summer of 1950, when it in turn was replaced on the island of Oahu, and subsequently throughout the Islands by *Opius oophilus* Fullaway, an egg-larval parasite. *O. oophilus* has been overwhelmingly predominant since it initially replaced *O. vandenboschi* and appears destined to continue in this role. This succession of parasites just mentioned is shown in figure 1. The progress and status of these parasites have been described by Bess *et al.* (1950) and van den Bosch *et al.* (1951).

The replacement which has taken place among the parasites of the oriental fruit fly has not been without precedent in Hawaii, for a somewhat similar development occurred after the introduction of parasites to combat the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann). In the latter case, *Opius humilis* Silvestri was replaced by *Opius tryoni* Cameron and *Opius fullawayi* (Silvestri). The interrelations of these parasites were studied by Pemberton and Willard (1918), who concluded that the replacement occurred because *O. humilis* larvae were almost invariably destroyed by *O. tryoni* and *O. fullawayi* when they occurred together in the same hosts. These authors found that larvae of *O. tryoni* and *O. fullawayi,* being very active and armed with strong falcate mandibles, mangled the sluggish larvae of *O. humilis.*

The investigations in the present paper were made in an attempt to unravel the reasons for the successive rise to predominance by the above opiine parasites of *D. dorsalis.*

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[2] Now Assistant Entomologist, Department of Biological Control, University of California Citrus Experiment Station, Riverside, California.

[3] The authors wish to acknowledge the advice and suggestions given by Drs. H. A. Bess and I. M. Newell during the course of the investigations and the preparation of the manuscript.

Methods

The interrelations of the three species of *Opius* when they occur together in the same *D. dorsalis* larvae were studied in the attempt to unravel the reasons for the parasite succession. The interrelations of the three species of *Opius* were studied by exposing the host to parasitism as described below. The fate of the parasites when they occurred together in the same host was determined by dissecting the parasitized larvae and puparia at various intervals, and rearing the remainder of the sample through to adult emergence.

In obtaining parasitism by two parasite species (in this case *O. oophilus* and *O. vandenboschi*) the following steps were taken: (1) an uninfested firm, ripe guava fruit was placed in a cage with *D. dorsalis* adults and left until the desired number of eggs was deposited; (2) the fruit was then removed from the cage and immediately exposed to *O. oophilus* females (which oviposit in the eggs) for about 24 hours; (3) the fruit was next exposed to *O. vandenboschi* females (which oviposit in first instar larvae) for a period of 24-48 hours; and (4) the fly larvae were removed from the fruit and placed in a dish of blended papaya-yeast medium in a rearing container (Newell *et al.*, 1951).

After about 24 hours, larval samples were taken from the rearing container and dissections were begun to determine the condition of the parasite eggs and larvae. In making the dissection each larva was placed in a drop of saline solution on a depression slide and opened under a dissecting microscope. Dissections were made from time to time until sufficient larvae were dissected and the remainder of the parasitized host sample was permitted to complete development. The parasitization, based on the emergence of adult parasites, was used to supplement the data obtained by dissection.

The three parasites could be readily differentiated in the egg stage and first instar larvae of *O. longicaudatus* could be easily distinguished from those of *O. vandenboschi* and *O. oophilus*. The eggs of *O. longicaudatus* and *O. oophilus* are about equal in size at time of deposition but are quite different in shape. The eggs of the former have a distinctive mamilliform protuberance at each end. The egg of *O. vandenboschi* is longer than those of *O. longicaudatus* and *O. oophilus* at the time of deposition (van den Bosch and Haramoto, 1951). A further difference in the egg of *O. longicaudatus* from those of *O. vandenboschi* and *O. oophilus* is the great increase in size of the former prior to hatching. The eggs of *O. vandenboschi* and *O. oophilus* swell only slightly before eclosion. The heads of first instar larvae of *O. longicaudatus* are heavily sclerotized while those of *O. vandenboschi* and *O. oophilus* lack this sclerotization. Larvae of *O. vandenboschi* and *O. oophilus* could not be distinguished from each other but were differentiated by the chorions which were always associated with them.

In the studies involving *O. longicaudatus*, which attacks larger fruit fly larvae, essentially the same experimental procedure was followed except that the host larvae were allowed to develop to the late second instar or early third instar before being exposed to this parasite.

Experimental Results

Multiple-Parasitism

O. vandenboschi and *O. longicaudatus*: A typical test of laboratory series will serve as the basis for discussion of the interrelations of *O. vandenboschi* and *O. longicaudatus*. This test originally involved 84 fruit fly larvae, 28 of which were dissected and the remaining 56 held until emergence.

Twenty-seven of the 28 larvae dissected contained eggs and larvae of *O. vandenboschi*, and 23 of the 28 contained *O. longicaudatus*. Twenty-two of the 28 larvae contained eggs or larvae of both parasites, while 5 larvae contained *O. vandenboschi* only, and a single individual contained *O. longicaudatus* only. All of the 28 larvae were parasitized (Fig. 2).

In many cases the development of *O. longicaudatus* eggs was inhibited when *O. vandenboschi* larvae occurred with them in the same host larva. However, this inhibition of development of *O. longicaudatus* eggs did not occur in all hosts, for some of them produced normal first instar larvae in the presence of *O. vandenboschi*. Fifteen of the 22 host larvae that contained both parasites had either well developed eggs or first instar larvae of *O. longicaudatus* within them. The development of eggs in the remaining host larvae was retarded much beyond the normal incubation period.

Twelve of the 56 larvae held for emergence failed to mature. Forty-three parasites and one fly emerged. Of the parasites that emerged, 37 were *O. vandenboschi* and 6 were *O. longicaudatus* (Fig. 2).

The first instar *O. longicaudatus* larvae are strongly mandibulate, very active, and they sometimes killed the sluggish, weakly mandibulate *O.*

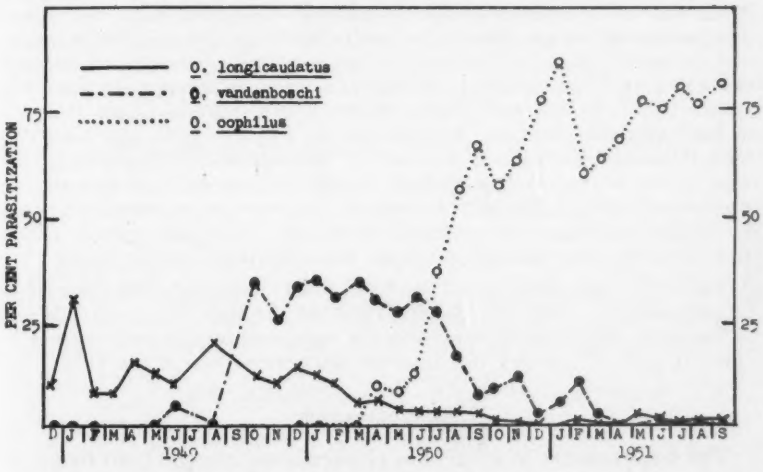
O. longicaudatus
O. vandenboschi
O. oophilus
PER CENT PARASITIZATION
75
50
25
D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S
1949
1950
1951

Fig. 1. Succession of oriental fruit fly parasites on the island of Oahu during the period December 1948 to September 1951. (Data obtained from infested guava fruits.)

vandenboschi larvae associated with them in the same host larva. However, observations at the time of dissection, as well as rearing records, indicated that mortality of *O. vandenboschi* produced in this manner was usually relatively low. In the test discussed above four dead (collapsed) *O. vandenboschi* larvae were noted at the time of dissection and the reared portion of the sample indicated that approximately the same degree of mortality occurred in it. Normally, therefore, when the two species occurred together, *O. vandenboschi* completed its development, while *O. longicaudatus,* except where it killed the *O. vandenboschi* larvae, starved.

These data, corroborated by additional tests, indicate that a few *O. longicaudatus* larvae were able to survive in competition with *O. vandenboschi* in the same host individual but that in most instances the *O. longicaudatus* larvae died.

O. oophilus and *O. longicaudatus:* The interrelations of *O. oophilus* and *O. longicaudatus* were studied in the same manner as described for *O. vandenboschi* and *O. longicaudatus.* Essentially the same type of relationship was found to exist as with *O. vandenboschi* and *O. longicaudatus.* However, *O. oophilus* possibly has a slightly stronger inhibitory effect on hatching of the *O. longicaudatus* eggs.

O. oophilus and *O. vandenboschi*: Studies of *O. oophilus* and *O. vandenboschi* revealed that an entirely different interrelationship exists between these two species than that between these species and *O. longicaudatus.*

As mentioned earlier, *O. oophilus* attacks fruit fly eggs and *O. vandenboschi* the early first instar larvae. Thus, to study the interrelations of these parasites, for the most part it was the first and second instar host larvae that were dissected, since the chorion associated with the respective parasite larvae are difficult to find in the larger larvae. The examination of several hundred larvae was rather easily accomplished because of the relatively small size of the host in relation to the parasite eggs and larvae. Ninety larvae were found, each of which contained eggs or larvae of both of these parasites. None of the *O. vandenboschi* eggs found in these 90 host larvae showed evidence of development. In many cases, the dead *O. vandenboschi* eggs showed considerable internal disorganization and were usually collapsed. A total of 25 host larvae containing only *O. vandenboschi* were encountered; 23 of these contained parasite larvae and the other two unhatched turgid, and apparently viable eggs.

The inhibitory effect of *O. oophilus* and *O. vandenboschi* appears to be physiological, since no visible injury to the eggs was observed, and in the early stages of degeneration the eggs were turgid and normal in every respect, except for the internal disorganization of the yolk.

Superparasitism

The large number of dissections of parasitized oriental fruit fly larvae in the studies reported above provided an opportunity to obtain information on the fate of eggs and larvae of the different parasites when

superparasitism was involved. Superparasitism was found to be common. Five to 10 individuals of *O. longicaudatus* were often found in a single host larva and in one instance 16 first instar *O. longicaudatus* larvae were found in a third instar *D. dorsalis* larva. Two eggs or larvae of *O. vandenboschi* were frequently encountered in a host larva but this was the maximum number found. As many as 4 eggs of *O. oophilus* were found in an individual host, but like *O. vandenboschi,* 2 eggs were more commonly found. Since all three of these parasites are solitary, only one completes its development in a host.

The elimination of the supernumerary individuals is different with *O. longicaudatus* than with *O. vandenboschi* and *O. oophilus.* Larvae of *O. longicaudatus* engage in a vigorous physical struggle. The various individuals within a host larva attack each other with their powerful mandibles, until a lone survivor remains. With *O. vandenboschi* and *O. oophilus,* the first larva to hatch invariably prevents the others from developing. Death is due to a physiological reaction. In some instances, this inhibitory reaction prevented the eggs from hatching even when the embryos were fully developed. More commonly, however, the eggs hatched, but the young larvae died without evident development. Suppressed eggs and larvae usually exhibited a granulated appearance when found associated with vigorous surviving larvae.

Discussion

The clear-cut picture of parasite succession probably would never have unfolded if the sequence of liberations had been different, and it was a fortunate circumstance that the release and establishment of the

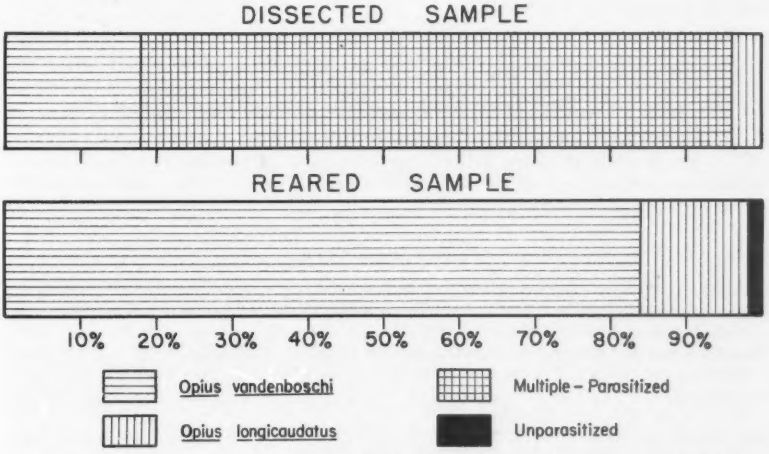

Fig. 2. Chart showing results obtained in multiple-parasitism studies with *Opius vandenboschi* Fullaway and *Opius longicaudatus* (Ashmead).

three species in the order mentioned revealed the interactions among them.

The early prominence of *Opius longicaudatus* in Hawaii probably resulted from the liberation of large numbers of insectary-reared specimens. This parasite was more easily handled under insectary conditions than *O. vandenboschi* and as a result much larger numbers were produced and released in the early part of the program. This initial advantage over *O. vandenboschi* was eventually lost as the latter multiplied rapidly on the heavily infested summer guava crop of 1949.

Undoubtedly the habit of attacking the highly vulnerable first instar host larvae was a major factor contributing to the replacement of *O. longicaudatus* by *O. vandenboschi*. However, studies of multiple-parasitism indicated that the interrelations of the two species within the same host larva also influenced this succession.

The egg-attacking habit of *O. oophilus* together with the invariable inhibition of the egg development of *O. vandenboschi* when both of these species occur together in the same host larvae were probably the major factors which enabled the former species to assume the predominant role in the parasitization of *D. dorsalis* in Hawaii since the summer of 1950.

Summary

The successive rise to predominance by the three most successful parasites of the oriental fruit fly, *Dacus dorsalis* Hendel, in Hawaii is discussed.

Data obtained primarily from laboratory studies of the interrelations of the three most successful parasites of the oriental fruit fly, *D. dorsalis*, are presented and discussed.

Data are presented which show that *O. longicaudatus* eggs and larvae were inhibited in their development in hosts which contained either of the other two parasites. When *O. vandenboschi* and *O. oophilus* occurred in the same host, the latter prevented the former from developing.

Data presented on superparasitism indicated that supernumerary larvae of *O. longicaudatus* were killed mechanically. However, death of supernumerary individuals of *O. vandenboschi* and *O. oophilus* was attributed to a physiological inhibition.

LITERATURE CITED

Bess, H. A., Robert van den Bosch, and **Frank Haramoto.** 1950. Progress and status of two recently introduced parasites of the oriental fruit fly, *Dacus dorsalis* Hendel, in Hawaii. Haw. Ent. Soc. Proc. 14(1):29-33.

Newell, Irwin M., Robert van den Bosch, and **Frank H. Haramoto.** 1951. An improved method of rearing field-collected fruit fly larvae. Haw. Ent. Soc. Proc. 14(2):297-299.

Pemberton, C. E., and **H. F. Willard.** 1918. Interrelations of fruit fly parasites in Hawaii. Jour. Agric. Res. 12(5):285-296.

van den Bosch, Robert, H. A. Bess, and **F. H. Haramoto.** 1951. Status of oriental fruit fly parasites in Hawaii. Jour. Econ. Ent. 44(5):753-759.

———, and **Frank H. Haramoto.** 1951. *Opius oophilus* Fullaway, an egg-larval parasite of the oriental fruit fly discovered in Hawaii. Haw. Ent. Soc. Proc. 14(2):251-255.

Further Studies on Hawaiian Agromyzidae (Diptera) with Descriptions of Four New Species[1]

By KENNETH E. FRICK

IRRIGATION EXPERIMENT STATION, PROSSER, WASHINGTON

Since the first report on the Agromyzidae of Hawaii (Frick, 1952b), D. Elmo Hardy and Wallace C. Mitchell have reared and forwarded to the writer numerous specimens for study. Eleven species were listed in the 1952 paper. Three more are herein described as new, but one is based upon a previous misidentification. This brings the total to thirteen for the Hawaiian Islands. Of these species, six are known to have been introduced. One species is described from Canton Island and it is believed to be the only species known from that island.

Frick (1952a, b) followed Hendel (1931) in the numbering of the dorso-central setae from the posterior of the mesonotum towards the head. In order to conform to accepted usage by American authors, these setae are herein numbered so that the first is the anteriormost, or presutural, and the fourth is nearest the scutellum. It is hoped that this change will not work a hardship upon those who use the descriptions and the keys.

In previous papers the size of the adults was given in terms of body length. It has been found that the length of the wing is a better criterion of size, because the body so frequently dries in a curled position. Wing length is very similar to body length and may be so considered if body size is desired.

Paratypes of each new species are deposited in the collections of the University of Hawaii, Hawaiian Sugar Planters' Association, B. P. Bishop Museum, Zoologisches Museum, Berlin, and of the writer.

Genus **Melanagromyza** Hendel

Melanagromyza splendida new species

Male—Shining black; head with frontal vitta dull black, genovertical plates and frontal triangle shining fuscous, proboscis brown; mesonotum and abdominal tergites with a faint metallic greenish tinge; legs and tarsi fuscous; wing base brown, calypter with margin and fringe white; halter brownish-black.

Head—As seen in profile, genovertical plate not raised above eye margin; eye longest dorsad of antennae, about three-fourths as long as high, pubescent, especially on dorsal one-fourth, where setulae are subequal to the orbital setulae in length; gena about one-seventh the eye height, smoothly rounded ventrally, not projecting anteriorly; vibrissa small, about twice as long as subcranial setae; about six setae on each side of subcranial margin. Frontal vitta about two-thirds as long as wide; vertical triangle extending nearly two-thirds of the distance from anterior ocellus to lunule. Genovertical plates each widening from vertex until about one-fourth the distance between eyes at

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point of insertion of the dorsal lower frontoorbital seta and about opposite the anterior tip of the frontal triangle; each bearing two upper and two lower frontoorbital setae; dorsal upper frontoorbital upwardly and outwardly directed, ventral upwardly directed only, both lower frontoorbitals strongly inwardly directed; all four relatively short and slender, upper pair subequal to the postvertical seta in length, lower pair slightly shorter; upper pair very close together, dorsal lower seta slightly farther removed from ventral upper than the latter is from the dorsal upper; ventral lower frontoorbital distant from others, about its own length away; orbital setulae very numerous, long, slender, most erect, some ventral setulae dorsally, and a few dorsal setulae anteriorly, directed. Lunule of moderate size, half as high as length of frontal vitta, terminating dorsally in a deep groove. Antennae relatively large; third segment rounded, setulae less than basal aristal thickness in length; arista extremely long, twice an upper frontoorbital in length, pubescence extremely fine. Proboscis not greatly elongate, about half as long as eye height.

Thorax—Mesonotum with two dorsocentral setae, anterior about two-thirds as long as posterior; intraalar relatively strong, slightly more than half as long as posterior dc; inner postalar minute, less than one-seventh as long as outer postalar; acrostichal setae short, very numerous, in about eight rows extending posterior to anterior dc, sparse posteriorly but continuing back to slightly beyond posterior dc. Scutellum with distal pair of setae very close together and three times as far from basal pair as from each other. Humerus with about six setulae plus the humeral. Anepisternum with one seta dorsad to and one ventrad to the anepisternal, about five setulae in a group near dorsal margin. Katepisternum with two strong setae anterior to the katepisternal, posterior one about two-thirds as long as katepisternal.

Legs—Fore tibiae without distinguishable mid-tibial spurs; mid-tibiae each with a pair of strong spurs midway between base and apex.

Wing—Slightly more than twice as long as wide; costa extending to termination of M_{1+2}; second, third, and fourth costal sections as 14 : 4 : 3 in length; cross vein r-m beyond center of cell 1-M_2, five-eighths of the distance to m-m; m-m slightly more than its own length from r-m; M_{1+2} with ultimate section about four times as long as penultimate; M_{3+4} with ultimate section about five-eighths as long as penultimate.

Abdomen—Covered with short setae, interspersed with some longer, subequal to a tergal length.

Size—2.25 mm. in wing length.

Female—Slightly larger, 2.5 mm. in wing length; head with frontoorbital setae more robust, ventral lower seta about one and a half times as far from the dorsal lower as the latter is from the ventral upper; about half as many orbital setulae as in holotype; eyes with very short fine pubescence; vertical triangle extending two-thirds of distance from anterior ocellus to lunule; abdomen with seventh segment subequal to the sixth tergite in length, short, conical, shining black.

Holotype ♂—Kamuela, Hawaii, December 5, 1950, reared from a larva mining celery (*Apium graveolens* L.), deposited in the U. S. National Museum. Allotype ♀—Topotypical, same data as holotype, deposited in same collection as holotype. Paratypes—2 ♂♂, 4 ♀♀, topotypical, same data as holotype; 2 ♂♂, 1 ♀, Kurtistown, Hawaii, July 23, 1941, S. Takei, collector, ex celery; 3 ♂♂, 2 ♀♀, Glenwood, Hawaii, August, 1951, reared from larvae mining lettuce leaves; 3 ♂♂, 6 ♀♀, Hilo, Hawaii, August, 1951, ex lettuce.

Other material studied—1 ♂, 2 ♀♀, Kunia, Oahu, September, 1951, D. E. Hardy, ex squash leaf; 1 ♀, Waipahu, Oahu, January 10, 1941, W. C. Look, ex sweet potato; 2 ♀♀, Honolulu, Oahu, July 14, 1931, F. X. Williams; 1 ♂, 4 ♀♀, Waipio, Oahu, February, 1952, D. E. Hardy.

Hering (1951) presented a classification of the *Melanagromyza* species of the Indo-Australian Region. *M. splendida* belongs to the group hav-

ing the margin of the calypter white and cross vein r-m beyond the center of cell 1-M_2. From the species included in this group, *splendida* may be separated from the Formosan species, *producta* (Malloch), 1914, and *prolifica* (Malloch), 1914, by the pilose eyes; from *trispina* (Malloch), 1927, from Australia, by the two pairs of dorsocentral setae; and from the Javanese species, *sojae* (Zehntner), 1900, by the shining frontal triangle and the lack of a purplish tinge on the thorax, and from *erythrinae* (de Meijere), 1910, by the orbital setulae being mostly erect with only a few posteriorly directed and the lack of any metallic dark green color on the frontal triangle.

The only North American species in this genus known to have pilose eyes is *virens* (Loew). Dr. P. J. Darlington, Jr., Curator of Insects, at the Museum of Comparative Zoology, kindly compared specimens of the Hawaiian species with Loew's type. He found that *virens* is larger and has the orbital setulae, "more irregular in direction, being considerably mixed and even criss-crossed," but otherwise very similar.

Genus **Ophiomyia** Braschnikov

Ophiomyia scaevolae new species

Agromyza sp.: Van Zwaluwenburg, 1942, Proc. Hawaii. Ent. Soc. 11:148.

Ophiomyia sp.: Frick, 1952, Proc. Hawaii Ent. Soc. 14:515.

Male—Black, subshining. Head with frontal triangle brown, shining; frontal vitta and genovertical plates dull, latter with a brownish tinge; lunule and mesofacial plate dark brown; proboscis brown. Thorax with legs fuscous; wing base dark, calypter white, also margin and fringe; halter dark brown.

Head—Seen in profile, about twice as high as long; gena relatively large, nearly one-third as high as the eye height, about six setae on each side along subcranial margin; vibrissal angle produced, but not extending anteriorly as far as the eye, vibrissa a fasciculus of setae, long, strongly upcurved on outer one-third, nearly reaching third antennal segment. Frontal triangle very large, at vertex nearly reaching genovertical plates laterally and extending to lunule; genovertical plates narrow, each about one-sixth the distance between eyes; each bearing a pair of upwardly and slightly outwardly curving upper frontoorbital setae, and a pair of lower frontoorbitals; upper subequal in length, lower shorter, all slender, relatively short, longest being only three-fourths the length of the postvertical setae; about six short orbital setulae on each plate. Lunule low, about one-sixth of distance from antennal bases to anterior ocellus; mesofacial plate strongly projecting ventrally, with a narrow median carina, widening between antennae. Antennae divergent, third segment rounded, arista about three times as long as this segment is in diameter. Proboscis relatively elongate, about half as long as head height.

Thorax—Mesonotum with two dorsocentral setae, posterior the stronger, anterior slender, about five-eighths as long as posterior; intraalar weak, about three-eighths the posterior dorsocentral; inner postalar minute, only one-fourth the outer, which is subequal to the posterior dorsocentral; acrostichal setae short, numerous, in about seven rows back to anterior dorsocentral, only about ten posterior to this pair of setae; humerus with about four setulae plus the humeral.

Wing—Slightly more than twice as long as wide; costal segments in the proportions of 9 : 2.5 : 2, terminating at end of M_{1+2}; cross vein r-m about two-thirds of the distance from base of cell 1-M_2, very close to cross vein m-m; m-m less than its own length from r-m; M_{1+2} with penultimate section about one-seventh the ultimate in length; M_{3+4} with ultimate section about three-fifths the penultimate, ending at wing margin.

Legs—No distinguishable spurs on any of the tibiae midway between base and apex.

Size—1.5 mm. in wing length.

Female—Subequal to male in size; head with gena about one-fourth eye height, bearing a single strong vibrissa, about half as long as the arista; abdomen with seventh segment black, shining, nearly twice as long as sixth abdominal tergite.

Holotype ♂—Canton Island, November 5, 1940, R. R. Danner, collector, reared from a larva mining a leaf of *Scaevola frutescens*, "naupaka" (Goodeniaceae), deposited in the U. S. National Museum. Allotype ♀ – Topotypical, September, 1941, R. H. Van Zwaluwenburg, ex *Scaevola* leaf, deposited in same collection as holotype. Paratypes—1 ♂, 3 ♀♀, topotypical, same data as allotype; 2 ♀♀, topotypical, October, 1950, N. L. H. Krauss; 1 ♂, topotypical, September, 1950, N. L. H. Krauss.

Five other specimens from Canton Island, only one of which was reared, were left out of the type series because of inferior condition.

Ophiomyia scaevolae can be quickly separated from the Pacific area species, *lantanae* (Froggatt), 1919, and *anguliceps* (Malloch), 1914, and the European species, *maura* (Meigen), 1838, and *proboscidea* (Strobl), 1900, by the white margin and fringe of the calypter. Two *Ophiomyia* species from the Pacific area have the calypter entirely white and these are *cornuta* (de Meijere), 1910, from Krakatau and *leucolepis* Bezzi, 1928, from Fiji. These last two species are both very similar to *scaevolae*. Each was described from a single unreared male and only a study of the types can positively determine whether three species are involved. At present, it seems better to give a name to the species mining *Scaevola* leaves on Canton Island until such time as the types of the other two species can be studied.

Bezzi states that the ultimate and penultimate sections of M_{3+4} are subequal in length. In *scaevolae* the ultimate is only three-fifths as long as the penultimate. Based on de Meijere's descriptions (1910, 1922) *cornuta* may be distinguished by the black frontal triangle and proboscis, both of which are brown in *scaevolae*. De Meijere's figure (1910) shows the vibrissal angle extending anteriorly as far as the eye, while in *scaevolae* this angle is not as far forward as the anterior margin of the eye.

Genus **Phytobia** Lioy

Subgenus **Praspedomyza** Hendel

Phytobia (Praspedomyza) cocculi new species

Male—Fuscous with yellow markings. Head yellow except back of head, eye margins from posterior median curve of eye to vertex, ocellar triangle, and aristae. Thorax with mesonotum fuscous, scutellum concolorous; humerus brown, narrowly encircled with yellow, metapleural triangle yellow; aneptisternum brown centrally, narrowly ringed with yellow on both sides and ventral margin, dorsal margin yellow for about one-third of anepisternal height; katepisternum brown, narrowly yellow dorsally, metapleural callus light brown; wing base yellow, wings grayish; calypter gray, margin and fringe grayish-black; halter yellow. Legs with femora primarily brown, spotted with yellow and distally narrowly yellow, tibiae and tarsi brown. Abdomen fuscous, each tergite very narrowly yellow distally; ninth tergite brownish-black, cerci yellow.

Head—As viewed in profile, eye about four-fifths as long as high; gena midway between posterior angle and vibrissa, about one-fifth eye height; genovertical plate not raised above eye margin. Frontal vitta about twice as long as wide, sunken below geno-

vertical plates, striated with vertical rows of minute brown spots; genovertical plates broad, each about one-third width between eyes; each bearing two upwardly directed upper frontoorbital setae and two upwardly and inwardly curving lower frontoorbitals, all subequal in length and subequal to the long ocellar setae; orbital setulae short, upwardly directed, about ten on each side. Antennae with third segment rounded, setulae subequal to basal aristal thickness in length; arista subequal in length to eye length. Vibrissa long, nearly twice as long as strong subcranial setae, of which there are about five on a side.

Thorax—Mesonotum with 3+1 dorsocentral setae, first three elongate, subequal in length, each about three-fourths as long as fourth dc, all subequally spaced from each other; intraalar minute, barely longer than any of ten setulae in each intraalar row posterior to the transverse suture; inner postalar long, about three-fourths the outer postalar; acrostichal setae numerous, in about five irregular rows to third dc, sparser posteriorly, reaching fourth dc. Humerus with about five setulae plus the humeral. Anepisternum with one setula dorsad to and one ventrad to the anepisternal, two setulae near dorsal margin.

Wing—Slightly less than half as wide as long; costa terminating at tip of wing, at end of vein M_{1+2}; cross vein r-m at center of cell 1-M_2; cross vein m-m one and a half times its length from r-m; M_{1+2} with ultimate section about eight times as long as penultimate; M_{3+4} with ultimate twice as long as penultimate.

Legs—No distinguishably elongate setae or spurs on the femora.

Size—1.6 mm. in wing length.

Female—Subequal in size to male; mesonotum with fourth dorsocentral one-fourth again as far removed from third as others are from each other; abdomen with sixth tergite about one-fourth yellow distally; seventh segment dull black, covered with minute setulae, subequal to sixth tergite in length.

Holotype ♂—Pupukea, Oahu, March 6, 1932, O. H. Swezey, collector, reared from a larva mining a *Cocculus* leaf, deposited in the U. S. National Museum. Allotype ♀—Topotypical, same data as holotype, deposited in same collection as holotype. Paratypes—2 ♂♂, 1 ♀, topotypical, same data as holotype; 3 ♀♀, Kahana, Oahu, January 1, 1928; 2 ♀♀, Kuliouou, Oahu, May 4, 1924; 1 ♀, Mt. Kaala, Oahu, February 18, 1923; 1 ♂, 2 ♀♀, Mt. Kaala, Oahu, no date (all of the foregoing paratypes reared by O. H. Swezey from larvae mining *Cocculus* leaves); 1 ♂, Mt. Kaala, Oahu, April, 1952, L. D. Tuthill.

This species may be easily separated from the North American species, *subinfumata* (Malloch), 1915, by the yellow frontal vitta, rounded third antennal segment, and the very weak intraalar seta. From the similar appearing *approximata* (Hendel), 1920, *cocculi* differs in having cross vein r-m approximately at the center of cell 1-M_2 and in having the anterior femora narrowly yellow distally.

Genus **Liriomyza** Mik

For the convenience of those working with the leaf-mining Diptera in Hawaii a key is herein included to the species the larvae of which are known to attack agricultural crops. It is stressed that the key must be used with reservations. The writer has specimens, collected by sweeping, that do not belong to any of the five species. Therefore, all specimens being determined should be carefully checked with the original descriptions.

Key to Species Attacking Agricultural Crops

1. Mesonotum with inner postalar seta one-half or less as long as the outer postalar 2
   Mesonotum with inner postalar distinctly more than half as long as outer..... 4
2. Head with both vertical setae arising from the black of the vertex; outer vertical at edge of black..... 3
   Head with outer vertical arising from the yellow of the vertex, outer from the black ..... **Liriomyza minutiseta** Frick
3. Mesonotum with first dorsocentral seta about one-third as long as fourth; abdomen with only second tergite yellow laterally..... **Liriomyza pullata** Frick
   Mesonotum with first dc about half as long as fourth; abdomen with all tergites narrowly yellowish laterally..... **Liriomyza canomarginis** Frick
4. Head with genovertical plates entirely yellow; eye about half as long as high ..... **Liriomyza hawaiiensis** Frick
   Head with genovertical plates narrowly darkened; eye three-fourths as long as high ..... **Liriomyza brassicae** (Riley)

Many specimens have been received for determination during the past year. All of the new host and locality records for each species, together with one correction of a previous determination, follow:

Liriomyza pullata Frick, 1952

This is one of the large species. The females have a wing length of 1.5 mm. The species is not common.

3, Honolulu, Oahu, September, 1950, W. C. Mitchell, ex *Aster* sp.; 1, Poamoho, Oahu, July, 1950, W. C. Mitchell, ex tomato.

Liriomyza canomarginis Frick, 1952

No additional specimens were found that belong to this apparently rare bean miner. The females have a wing length of 1.25 mm., making this species one of the smaller. The record of the male paratype taken at a light in Honolulu is in error. The specimen belongs to the closely related *L. pullata.*

Liriomyza minutiseta Frick, 1952

Another small species, as the female wing measures only 1.25 mm. in length. The puparium has three bulbs on each posterior spiracle. This is apparently a rather common species, and attacks a variety of crop plants.

6, Kunia, Oahu, November 23, 1951, W. C. Mitchell, ex *Lycopersicon pimpinellifolium;* 6, Honolulu, Oahu, September 7, 1951, W. C. Mitchell, ex eggplant and Chinese cabbage ("won bok") ; 3, Poamoho, Oahu, November, 1951, W. C. Mitchell, ex cauliflower; 1, Poamoho, Oahu, July, 1950, W. C. Mitchell, ex tomato; 5, Honolulu, Oahu, December, 1952, W. C. Mitchell, ex okra; 6, Honolulu, Oahu, December, 1951, W. C. Mitchell, ex pole bean; 3, Kona, Hawaii, July, 1952, H. A. Bess, ex pole bean.

Liriomyza hawaiiensis Frick, 1952

One of the larger species, the females having a wing length of 1.5 mm. There are three bulbs on each posterior spiracle of the puparium. This is by far the most common species, having been collected on five of the Hawaiian Islands attacking a large variety of crop plants, none of which are native.

11, Honolulu, Oahu, December 24, 1942, January 19, 1943, and April, 1946, N. L. H. Krauss, ex *Gynandropsis pentaphylla* D. C.; 6, Honolulu, Oahu, March, 1952, Van Zwaluwenburg, ex *Cleome* sp., 9, Poamoho, Oahu, November, 1951, W. C. Mitchell, ex cauliflower; 11, Poamoho, Oahu, July, 1950, W. C. Mitchell, ex cabbage and Chinese cabbage ("won bok"); 7, Honolulu, Oahu, September 7, 1951, W. C. Mitchell, ex cauliflower and Chinese cabbage; 4, Honolulu, Oahu, February, 1952, H. A. Bess, ex nasturtium; 6, Waiakoa, Maui, September 18, 1951, H. A. Bess, ex cabbage; 2, Wailua, Kauai, January 21, 1944, N. L. H. Krauss, ex Chinese cabbage.

Liriomyza brassicae (Riley), 1884

The females have a wing length of 1.5 mm. This species, the larvae of which mine various cruciferous plants, is frequently very common in the western United States. In Hawaii, it is much less common than *L. hawaiiensis*.

5, Honolulu, Oahu, October, 1951, W. C. Mitchell, ex white mustard cabbage; 6, Honolulu, Oahu, December, 1951, W. C. Mitchell, ex leaf mustard cabbage.

Genus Phytoliriomyza Hendel

Key to the Species of the World

1. Anepisternum ventrally at most one-third darkened 2
   Anepisternum ventrally at least one-half darkened 3
2. Ultimate section of M_{3+4} one and three-fourths as long as penultimate; back of head and vertex grayish ..... **formosensis** Malloch
   Ultimate section of M_{3+4} slightly more than twice as long as penultimate; only ocellar triangle grayish ..... **perpusilla** (Meigen)
3. Anepisternum ventrally about one-half darkened; cross vein m-m at an acute angle to penultimate section of M_{1+2} ..... **halterata** (Becker)
   Anepisternum dorsally with only a narrow yellow band; cross vein m-m approximately perpendicular to M_{1+2} ..... **montana** new species

Phytoliriomyza montana new species

Phytoliriomyza perpusilla (Meigen), Frick, 1952, Proc. Hawaii. Ent. Soc., 14:516.

Female—Grayish black, marked with yellow, dull, pollinose. Head with back, vertex, ocellar triangle, dorsal half of genovertical plates, antennae, and palpi grayish black; frontal vitta yellowish, striated with brown; mesofacial plate yellow, subantennal grooves brownish; gena and proboscis yellow. Thorax with mesonotum and scutellum grayish black, heavily pollinose; humerus and metapleural triangle brownish; anepisternum grayish black, narrowly yellow along anterior, dorsal, and ventral margins; katepisternum grayish black, rather broadly yellow dorsally; metapleural callus yellow; rest of pleura brownish. Wings tinged with gray, base yellow, calypter with margin and fringe brown; halter yellow, knob brownish. Legs grayish brown, femora narrowly

yellow distally. Abdomen grayish brown dorsally; sixth tergite about one-third yellow distally; pleural area yellow; seventh segment brownish black, shining.

Head—When viewed in profile, about three-fourths as long as high, subtriangular in outline, eye placed at an angle, ventrally more anterior; eye subrectangular, about two-thirds as long as high, covered with very short, colorless setulae; gena, midway between vibrissal angle and posterior angle, about one-fourth as high as eye height, vibrissa slender, short, about one and a half times as long as subcranial setae, about four setae on each side. Frontal vitta subquadrate, about three-fifths of width between eyes; genovertical plates narrow, each bearing two upper upwardly and outwardly curving frontoorbital setae, ventral about two-thirds as long as dorsal, and one slightly inwardly curving lower frontoorbital, subequal in length to the dorsal upper frontoorbital; orbital setulae anteriorly directed, about seven on a side; vertex with ocellar triangle small, ocellar setae subequal to dorsal upper frontoorbital in length. Antennae with third segment rounded, relatively large, equal to about one-third eye length in diameter, setulae less than basal aristal thickness in length; arista elongate, in length nearly equal to eye height, setulae minute.

Thorax—Mesonotum with 3+1 dorsocentral setae; fourth the longest, third slightly shorter, first and second subequal in length, about half as long as fourth; third one and a half times as far from fourth as from second, first and second and second and third subequally spaced from each other; acrostichals very sparse, seven in two rows extending posteriorly nearly to third pair of dorsocentrals, two setulae anterior to first dorsocentral in each row; no intraalar seta, but one or two setulae anterior to and one or two posterior to transverse suture; inner postalar small, slightly less than half as long as outer.

Wing—Slightly more than twice as long as broad; second, third, and fourth costal segments in the proportions of 4 : 1 : 1 in length; M_{1+2} terminating at wing tip, ultimate section about four times as long as penultimate; cross vein r-m at anterior third of cell 1-M_2; cross vein m-m twice its length from r-m, approximately perpendicular to penultimate sections of M_{1+2} and M_{3+4}; M_{3+4} nearly reaching wing margin, penultimate section about four-fifths as long as ultimate.

Size—1.5 mm. in wing length.

Male—Smaller, 1.25 mm. in wing length; coloration generally a little lighter; thorax with only four acrostichals and one seta immediately anterior to supraalar on each side in intraalar rows; wing with cross vein m-m at an angle slightly less than perpendicular to penultimate sections of M_{1+2} and M_{3+4}; male terminalia extended so that large aedeagal hood and elongate phallus are partially visible.

Holotype ♀—Koolau Gap, Haleakala Crater, elevation 7,000 feet, Maui, June, 1952, D. E. Hardy collector, deposited in the U. S. National Museum. Allotype ♂—Topotypical, same data as holotype, deposited in same collection as holotype. Paratypes—1 ♂, 4 ♀♀, topotypical, June, 1952, D. E. Hardy; 1 ♂, Holua, Haleakala Crater, Maui, June, 1952, D. E. Hardy; 1 ♀, Keanae, Maui, June, 1952, D. E. Hardy; 7 ♂♂, 1 ♀, Pupukea, Oahu, April, 1952, D. E. Hardy and W. C. Mitchell; 1 ♀, Waipio, Oahu, February, 1952, D. E. Hardy; 2 ♀♀, Mt. Kaala, Oahu, April, 1952, D. E. Hardy and L. D. Tuthill; 1 ♀, Mt. Kaala, Oahu, May, 1952, M. Tamashiro; 1 ♀, Mt. Kaala, elevation 4,000 feet, Oahu, July 25, 1946, W. W. Wirth; 1 ♂, Hawaii National Park, elevation 4,000 feet, Hawaii, March 3, 1946, W. W. Wirth.

The host plants of this species were not determined, according to D. E. Hardy. The larvae of *P. perpusilla* and *halterata* are known in Europe as stem miners and it is probable that the larvae of *P. montana* mine the stems of one or more native Hawaiian plants.

Frick (1952b) determined a rather teneral specimen of this species as *P. perpusilla*. With 22 more specimens available for study, it was quickly seen that the species was new. *P. montana* is most easily separated from the other known species by its dark coloration, particularly of the anepisternum and legs and by the unique character of pilose eyes.

Agromyza formosensis Malloch, 1914, was placed in *Phytoliriomyza* by Hennig (1941) on the basis of specimens in the collection of the "Deutsche Entomologische Institut." His figure of the male terminalia substantiates the change in generic position. *P. formosensis* is lighter in coloration than *montana*, and may be separated on the relatively short ultimate section of M_{3+4} from *perpusilla* and *halterata*. In *formosensis* this section is about one and three-fourths as long as the penultimate while in the other two species it is more than twice as long. *P. halterata* may be distinguished from *perpusilla* by the acute angle of cross vein m-m to the penultimate section of M_{1+2}, ultimate section of M_{3+4} being darkened for only one-third of the distance to the wing margin, and the darker coloration, especially of the anepisternum.

LITERATURE CITED

Bezzi, M.
1928. Diptera Brachycera and Athericera of the Fiji Islands based on material in the British Museum. Brit. Mus. (Nat. Hist.), pp. 163-167. London.

Frick, K. E.
1952a. A generic revision of the family Agromyzidae with a catalogue of New World species. Univ. Calif. Publ. Ent., 8(8):339-452.
1952b. Four new Hawaiian *Liriomyza* species and notes on other Hawaiian Agromyzidae. Proc. Hawaii. Ent. Soc. 14 (3) :509-518.

Hendel, F.
1931. Agromyzidae. In Lindner: Die Flieg. palaearkt. Reg., 59(52):1-64.

Hennig, W.
1941. Verzeichnis der Dipteren von Formosa. Ent. Beih., 8:172-176.

Hering, E. M.
1951. Ein neuer Sellerie-Feinde, *Melanagromyza apii*, sp. n. Ann. and Mag. Nat. Hist., (12) 4:736-745.

Malloch, J. R.
1914. Formosan Agromyzidae. Ann. Mus. Hungar., 12:306-336.
1927. Notes on Australian Diptera. No. XIII. Linn. Soc. New South Wales Proc., 52:339-446.

Meijere, J. C. H de
1910. Studien über südostasiatische Dipteren. IV. Die neue Dipteren-fauna von Krakatau. Tijdschr. Ent., 53:59-190 (Agromyzinae 160-162).
1922 Zur Kenntnis Javanischer Agromyzinen. Bijd. Dierkunde, 22:17-22.

Zehntner, L.
1900. De Kedelehboorder. De Indische Natuur, 1:113-137.

Insects and Other Invertebrates from Palmyra Atoll and Christmas Island

N. L. H. KRAUSS

BOARD OF AGRICULTURE AND FORESTRY, HONOLULU, HAWAII

The insects listed in this paper were collected during a brief visit made to Palmyra atoll and Christmas Island, in the Line Islands group, during February, 1948. A few of the identifications were made by the writer; for the others my thanks are extended to C. E. Pemberton, O. H. Swezey, R. H. Van Zwaluwenburg, D. Elmo Hardy, C. H. Edmondson, the late C. Montague Cooke, G. M. Ferris, Melville Hatch, C. H. Pope, W. J. Gertsch, C. R. Shoemaker, R. H. Arnett, B. D. Burks, A. B. Gurney, K. V. Krombein, C. F. W. Muesebeck, S. Parfin, R. I. Sailer, M. R. Smith, L. H. Weld, Willis W. Wirth and D. A. Young.

Palmyra atoll lies 90 miles south by west of Honolulu It is a horseshoe shaped group of about 50 islets, with a total area of about 250 acres. Christmas Island is 357 miles southeast of Palmyra. It is considerably larger than the latter, measuring about 24 by 35 miles, and having an area of about 223 square miles. The average annual rainfall for the brief period of record (3 to 5 years) is 169.16 inches for Palmyra and 37.36 for Christmas. Consequently there is a great difference between the lush vegetation of Palmyra and the dry, rather barren appearance of Christmas.

O. H. Swezey in 1914 listed 18 species of insects collected on Palmyra Island by Joseph Rock and C. Montague Cooke in July, 1913 (Proc. Hawaiian Ent. Soc., 3:15-16). None of the seven species he lists by full scientific name are represented in the present collection.

In addition to the insects and invertebrates listed below, the following animals were collected on Palmyra: hermit crabs, *Coenobita perlatus* Edwards, on a beach; land shells, *Tornatellina* (*Tornatellinops*) *variabilis* (Odhner), on coconut leaves, and *Opeas gracilis* (Hutton), under a board; and four specimens of the mourning gecko, *Lepidodactylus lugubris* (Duméril and Bibron).

CRUSTACEA

Isopoda

Alloniscus oahuensis Buddle-Lund. Palmyra, 7 specimens; Christmas, 1.
Ligia pallida Jackson. Palmyra, 1.
? *Nagara* sp. Palmyra, 3; Christmas, 1.
Philoscia sp. Palmyra, 4.
? *Sphaerillo* sp. Palmyra, 16.

Amphipoda

Orchestia floresiana Weber. Palmyra.

ARACHNIDA

Araneida

Scytoidae
Scytodes longipes Lucas. Palmyra, 2.
Scytodes striatipes (L. Koch). Palmyra, 4.

Pholcidae
Smeringopus elongatus (Vinson). Palmyra, 8.

Theridiidae
Coleosoma blandum Cambridge. Palmyra.
Latrodectus geometricus Koch. Palmyra, 1.
Theridion rufipes Lucas. Palmyra, 9.

Argiopidae
Neoscona (*Aranea*) *theisi* Walckenaer. Palmyra, 13.
Tetragnatha keyserlingi Simon. Palmyra, 3; Christmas, 1.

Agelenidae
New genus and subspecies of subfamily Ageleninae. Palmyra, 1.

Heteropodidae
Heteropoda regia (F.). Palmyra, 1.

Salticidae
Hasarius adansoni (Audouin). Palmyra, 3.
Menemerus bivittatus Dufour. Palmyra, 6.
Metaphidippus n. sp. Palmyra, 14.
Plexippus paykulli (Audouin). Palmyra, 6.
Sandalodes sp. Palmyra, 4.

INSECTA

Orthoptera

Blattidae
Genus uncertain, *Balta* or near. Christmas, 1.
Cutilia soror (Brunner). Palmyra, 2.
Periplaneta americana (L.). Palmyra, 1 seen, not collected.
Periplaneta australasiae (F.). Palmyra, 2 nymphs.
Probably *Pycnoscelus surinamensis* (L.). Christmas, 1 nymph.

Acridiidae
Atractomorpha ambigua Bolivar. Palmyra, 4.
Oxya chinensis (Thunberg). Palmyra, 1.

Tettigoniidae
Conocephalus saltator (Saussure). Palmyra, 2.

Gryllidae
Cycloptilum sp. Palmyra, 2.
Speonemobius tigrinus (Saussure). Palmyra, 1.

Dermaptera

Labiduridae
Euborellia annulipes (Lucas). Palmyra, 8.
Labidura riparia (Pallas). Christmas, 2.

Corrodentia

Lepidopsocidae
Nepticulomima sp. Palmyra, 1.

Odonata

Libellulidae
Pantala flavescens (F.). Palmyra, 1.

Hemiptera

Miridae
Trigonotylus brevipes Jakowlef. Palmyra, 10, Christmas, 1 adult, 4 nymphs.

Homoptera

Delphacidae
Sogata paludum (Kirkaldy). Christmas, 12.

Margarodidae
Icerya purchasi Maskell. Palmyra, 10.

Pseudococcidae
Ferrisiana virgata (Cockerell). Palmyra.
Pseudococcus brevipes (Cockerell). Palmyra.
Pseudococcus citri (Risso). Palmyra.

Neuroptera

Hemerobiidae
Sympherobius sp. probably *barberi* (Banks). Christmas.

Lepidoptera

Pyralidae
Piletocera signiferalis (Wallengren). Palmyra, 4.

Agonoxenidae
Agonoxena argaula Meyrick. Palmyra, larvae feeding on coconut leaves

Tineidae
Opogona sp. Palmyra, 3.

Gelechiidae
Stoeberhinus testaceus Butler. Palmyra, 1.

Phalaenidae
Plusia chalcites (Esper). Palmyra, 2.

Nymphalidae
Hypolimnas bolina (L.). Palmyra, 3 seen, not collected.

Coleoptera

Carabidae
Undet. sp. Palmyra, 7 specimens.

Hydrophilidae
Undet. sp. Palmyra, 29.

Pselaphidae
Undet. sp. Palmyra, 1.

Oedemeridae
Ananca bicolor (Fairmaire). Palmyra, 1.
Ananca decolor (Fairmaire). Palmyra, 3.
Sessinia livida (F.). Christmas, 13.

Elateridae
Conoderus pallipes (Eschscholtz). Palmyra, 1.

Cryptophagidae
Toramus sp., or something near this genus. Palmyra, 19.

Coccinellidae
Coelophora inaequalis (F.). Palmyra, 10.
Lindorus lophanthae (Blaisdell). Palmyra, 1.
Diomus notescens (Blackburn). Palmyra, 2.

Ptiliidae
Undet. sp. Palmyra, 2 specimens.

Scarabaeidae
Saprosites pygmaeus Harold. Palmyra, 31.

Hymenoptera

Evaniidae
Evania appendigaster (L.). Christmas, 1.
Evania sericea Cameron. Christmas, 2.

Eulophidae
Tetrastichus hagenowii (Ratzeburg). Palmyra, 1.

Diapriidae
Trichopria sp. Palmyra, 1.

Cynipidae
Kleidotoma (*Kleidotoma*) sp. Palmyra, 1.

Formicidae
Pheidole sp. Palmyra, 2 winged forms.

Vespidae
Polistes fuscatus var. *aurifer* (Saussure). Palmyra, 3; Christmas, 2.

Eumenidae
Pachodynerus nasidens (Latreille). Palmyra, 4; Christmas, 2.

Ampulicidae
Dolichurus stantoni (Ashmead). Christmas, 1.

Sphecidae
Sceliphron caementarium (Drury). Christmas, 1.

Megachilidae
Megachile fullawayi Cockerell. Palmyra, 1; Christmas, 3.

Diptera

Tipulidae
Styringomyia didyma Grimshaw. Palmyra, 4.

Tendipedidae
Species of Tendipedini. Palmyra, 1.

Heleidae
Dasyhelea sp. near *hawaiiensis* Macfie. Palmyra, 5; Christmas, 7.

Dolichopodidae
Chrysosoma n sp.? related to *leucochirus* Bezzi. Palmyra, 13; Christmas, 1.
Chrysotus javanensis de Meijere. Palmyra, 4.

Syrphidae
Ischiodon penicillatus Hull ? Palmyra, 4.
Tubifera (*Lathyrophthalmus*) *arvorum* (F.). Palmyra, 3.
Volucela (*Ornidia*) obesa (F.). Palmyra, 3.

Sarcophagidae
Sarcophaga peregrina (Robineau-Desvoidy) ? Palmyra, 12.

Calliphoridae
Chrysomyia megacephala (F.). Palmyra, 5.
Phaenicia sericata (Meigen). Palmyra, 5.

Muscidae
Atherigona excisa (Thomson). Palmyra, 6.
Musca domestica L. Palmyra, 2; Christmas, 1.

Tethinidae
Tethina insularis Aldrich. Palmyra, 14; Christmas, 1.

Otitidae
Scholastes lonchifera Hendel. Palmyra, 8.

Canaceidae
Nocticanace marshallensis Wirth. Palmyra, 23.

Ephydridae
Placopsidella cynocephala Kertész. Palmyra, 5.
Hecamede persimilis Hendel. Palmyra, 3.
Hostis guamensis Cresson. Palmyra, 5.
Discocerina mera Cresson Palmyra, 14.
Psilopa sp. near *girschneri* von Roeder. Christmas, 1.

Chloropidae
Cadrema pallida (Loew). Palmyra, 33.

Lonchaeidae
Lamprolonchaea aurea (Macquart). Palmyra, 4.

Hippoboscidae
Olfersia aenescens Thomson. Palmyra, 1.

Status of Ceratitis capitata in Hawaii following the Introduction of Dacus dorsalis and its Parasites

By HENRY A. BESS[1, 2]

ENTOMOLOGIST, UNIVERSITY OF HAWAII, COLLEGE OF AGRICULTURE, AGRICULTURAL EXPERIMENT STATION

(Presidential address, presented at the meeting of December 8, 1952)

Immediately following the discovery in 1946 of the oriental fruit fly, *Dacus dorsalis* Hendel, in Hawaii and its subsequent rapid increase to epidemic levels, the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), became extremely scarce at lower elevations where it had been a pest for more than three decades. Even though *C. capitata* is seldom found in the more tropical lowland areas, it is still a formidable pest of peaches and persimmons which are grown in more temperate areas at higher elevations. However, since the egg-larval parasite, *Opius oophilus* Fullaway, became firmly established, there has also been an appreciable reduction in the infestation in these areas.

The present study was made to determine the occurrence of, and infestation by *C. capitata* and *D. dorsalis* in the various ecological zones in Hawaii. There was hope that eventually there would be an opportunity to make a more intensive study designed to attempt to explain why *C. capitata* was replaced by *D. dorsalis* in the more tropical lowland areas.

Methods

The procedure followed in this study was to collect periodically host fruits from localities at elevations between sea level and about 5,000 feet, and subsequently recover the flies and parasites from the fruits as they emerged in the insectary. Most of the detailed data presented were obtained from fruits collected in four general areas: on Maui, in the Kula area at elevations between 2,000 and 4,000 feet; on Hawaii, in the Kona area between 700 and 2,500 feet, the Volcano area between 4,000 and 5,300 feet, and the Waikii area at approximately 4,800 feet. However, collections were obtained occasionally from widely scattered areas throughout the islands where fruits and *C. capitata* could be found.

Peaches (*Prunus persica* [L.] Batsch.), coffee (*Coffea arabica* L.), Jerusalem cherries (*Solanum pseudocapsicum* L.), guavas (*Psidium Guajava* L.), and loquats (*Eriobotrya japonica* [Thunb.] Lindl.), were the principal fruits collected. Special collections of guavas were made near the upper occurence of guavas where *C. capitata* was found still to occur in guavas, even though usually in small numbers.

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[2]The writer is indebted to F. H. Haramoto, T. Nishida, B. L. Pelot, C. S. Inada and E. T. Fukunaga for assistance in carrying out these studies.

Soon after collection, the samples of mature fruits were shipped to Honolulu via air, and held in an insectary on the University campus. The fruits were first counted and weighed and then (except guavas) placed on ¼-inch wire screen in 5-quart jars with a layer of sand into which the maggots entered on leaving the fruits. Guavas, on the other hand, were usually dissected and the maggots transferred to a papaya-yeast medium for development, as in the procedure followed in the more extensive studies on the establishment, spread, and build-up of the parasites imported to combat *D. dorsalis*. After emergence was complete, the number and sex of the flies and parasites were determined and the number of unemerged puparia recorded.

From the data obtained from the fruit samples an index of the total infestation or abundance of *C. capitata* and *D. dorsalis* was computed by two methods: one on the basis of the number of puparia per fruit, and the other on the basis of the number of emerged flies per fruit. Since the maggots and puparia of *C. capitata* and *D. dorsalis* are extremely difficult to distinguish apart, no attempt was made to determine the number of puparia of each. The index of abundance or infestation based on the number of emerged adults is considerably lower than that based of puparia, since parasitization alone often exceeded 50 per cent. However, it was useful for comparing the abundance of *C. capitata* with *D. dorsalis* in these fruit samples, and also the abundance of *C. capitata* in recent years with its abundance many years ago.

Status of Ceratitis capitata

The infestation by *C. capitata* in Hawaii has changed tremendously in the past 40 years. Within a year after *C. capitata* was first found in Honolulu in 1910 it became such a serious pest that widespread concern was aroused. A vigorous clean-up campaign was waged for three years, but in spite of it, the fly rapidly spread to the outer islands and became well established throughout the Territory. Since the fly thrived and spread even though an attempt was made to dispose promptly of all surplus fruits before, or as soon as, they ripened, its increase might be classed as being of an epidemic nature. However, there are no infestation or population data for this period available for comparison with those for subsequent years after the fly had reached a more stable and probably lower population level.

From 1916 to 1933 *C. capitata* was a serious pest (Willard and Mason, 1937). It has continued to cause damage at the higher elevations, but since 1947 it has rarely been seen at lower elevations.

Infestation in fruits that contained Dacus dorsalis.

The reduction in abundance of *C. capitata* at lower elevations following the introduction of *D. dorsalis* caused speculation as to the possible detrimental effects of *D. dorsalis* on *C. capitata*. Subsequently, studies were made to determine whether the larvae of *D. dorsalis* had an adverse effect on *C. capitata* larvae when they occurred together in individual fruits.

During the period between June 9 and August 4, 1949, data on emergence were obtained from ten or more individual peaches from 13 different collections. Of these individual fruits, 244 produced flies. Ninety-four of the fruits produced *C. capitata* alone, 79 *D. dorsalis* alone, and 71 produced both species. A total of 539 adults emerged from the 94 fruits that produced only *C. capitata*, 1,006 adults emerged from the 79 fruits that produced only *D. dorsalis*, and 467 *C. capitata* adults and 415 *D. dorsalis* adults emerged from the 71 fruits that produced both species. It is evident from these data, and those obtained from mechanically infested fruits in the insectary, that both species developed together successfully and in good numbers.

There were nine of the above 13 collections in which there were one or more fruits that produced *C. capitata* alone and also one or more fruits that produced both *C. capitata* and *D. dorsalis*. The number of *C. capitata* that emerged from fruits that produced only this species was not appreciably different from the emergence from fruits that also produced *D. dorsalis* (table 1).

Table 1. Comparison of the emergence of *C. capitata* from individual peaches that produced both *C. capitata* and *D. Dorsalis* with that from those that produced only *C. capitata*. Maui, 1949.

	C. capitata when *D. dorsalis* was present			C. capitata only		
Date collected	No. of fruits	No. of Cer. cap.	No. of Cer. cap. per fruit	No. fruits	No. of *C. c.*	No. of *C. c.* per fruit
June 9	20	140	7.0	5	24	4.8
June 9	20	95	4.8	8	44	5.5
June 30	4	8	2.0	4	12	3.0
July 12	1	1	1.0	3	8	2.7
July 12	3	11	3.7	1	2	2.0
July 15	4	32	8.0	19	113	5.9
August 3	7	44	6.3	4	58	14.5
August 4	3	26	8.7	3	19	6.3
August 4	7	108	15.4	2	15	7.5
Total	69	465	6.3	49	295	5.8

These data indicate that the number of *C. capitata* produced in the individual fruits was not reduced by *D. dorsalis*. A similar comparison between the emergence of *D. dorsalis* from fruits that produced only *D. dorsalis* and those that produced both species indicate that *C. capitata* did not affect adversely the production of *D. dorsalis*.

Infestation at different elevations.

As mentioned before, subsequent to the arrival of *D. dorsalis*, *C. capitata* became scarce at the lower elevations and has never recovered to any appreciable extent. To obtain information on the relative abundance of the two species at different elevations, special collections of fruits were made from time to time during the past four years to supplement the information being obtained from the numerous guava collections made throughout the islands in conjunction with the studies of the establishment, spread, and build-up of the various parasites introduced

to combat *D. dorsalis*. The more intensive of these collections were of peaches on Maui and of coffee berries in Kona, Hawaii, and these were supplemented with collections of loquats, Jerusalem cherries, and special collections of guavas.

Peaches. From June 9 to October 5, 1949, 70 collections of peaches were made at different elevations on Maui, shipped to Honolulu via air, and held in the insectary for fruit fly emergence. These collections produced a good deal of data on the infestation by and relative abundance of the two flies at these different elevations (table 2).

Table 2. Summary of data obtained from 70 collections of peaches from Maui, June 9-October 5, 1949.

Date	Elev. range	No. coll.	No. fruits	No. puparia	Emergence			% Cer. cap.
					Cer.	Dacus	*Opius* spp.	
6/14	800	1	24	842	2	804	0	0.2
6/ 9- 7/12	2,200-2,500	7	291	2,949	374	1,843	247	23.5
6/30- 8/22	2,500-2,800	11	365	6,522	2,117	2,942	510	39.8
6/30- 8/17	2,800-3,100	18	647	5,116	1,889	1,494	223	53.5
7/12-10/ 5	3,100-3,400	23	798	8,879	5,800	930	366	87.6
6/30- 8/17	3,400-3,700	7	222	1,256	565	75	18	85.1
7/25-10/ 5	3,700-4,000	3	54	247	159	8	21	98.0
Total		70	2,401	25,811	10,906	8,096	1,385	55.4

Total flies—19,002
Total emergence—20,387

The infestation based on the number of puparia of both flies per fruit decreased as the elevation increased (figure 1).

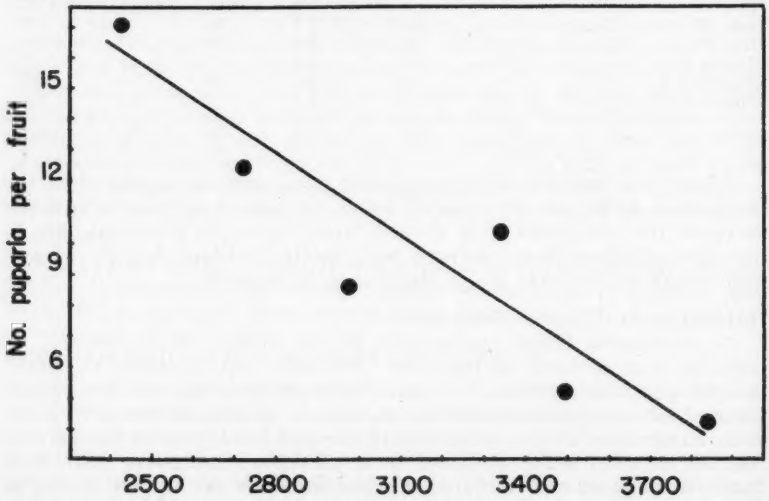

Figure 1. Infestation by *C. capitata* and *D. dorsalis* in peaches at different elevations on Maui, 1949.

As stated earlier, since the puparia of the two species could not be readily differentiated, it was necessary to use the number of adults that emerged, rather than the number of puparia produced, to estimate the infestation by each of the flies in the various collections. These emergence data indicated the average infestation by *C. capitata* was around 3 to 8 adults per fruit above 2,500 feet elevation, while only 2 adults emerged from the 24 fruits collected at the 800 foot elevation.

Coffee. Coffee is grown commercially in Kona, Hawaii, from an elevation of approximately 700 feet to slightly above 2,500 feet. Above 1,000 feet ripe coffee berries can be found throughout the year, even though they are more abundant in the fall. Collections of 300 ripe berries each have been made each month since August of 1949 on two plantations, one at 2,300 feet and the other at 1,200 feet and in a third plantation at 700 feet in the months when ripe berries were available. During this period, infestation data were obtained from a total of 105 collections composed of over 30,000 coffee berries. The combined infestation by both flies is shown graphically in figure 2.

Miscellaneous fruits. Many collections of Jerusalem cherries, loquats, and guavas were made in certain areas throughout the islands to obtain additional information on the occurrence of *C. capitata* and its interrelations with *D. dorsalis.* In addition a few collections of other fruits, such as apricots (*Prunus armeniaca* L.), plums (*Prunus* sp.), persimmons (*Diospyros kaki* L.f.), and English walnuts (*Juglans regia* L.) were obtained from which fruit flies were reared.

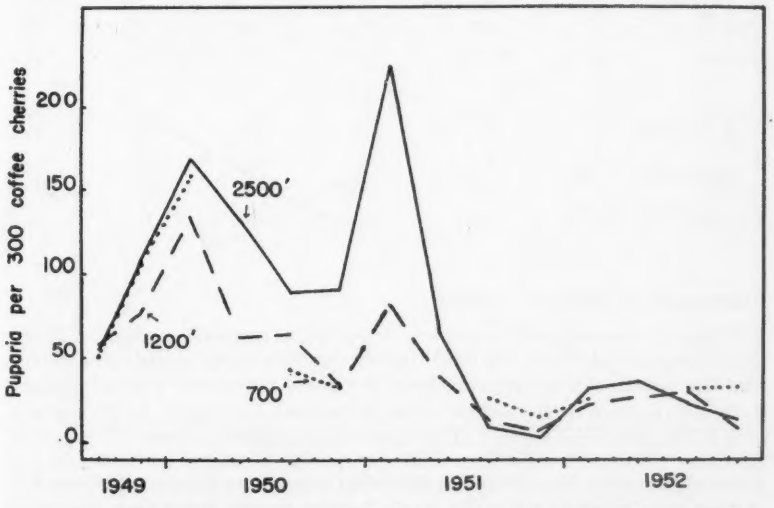

Figure 2. Infestation by *C. capitata* and *D. dorsalis* in coffee from three plantations at different elevations in Kona, Hawaii, August 1949 to December 1952.

Several collections of Jerusalem cherries were made from time to time along the Mauna Loa truck trail at elevations from 4,000 to 5,300 feet and at Waikii on the "Saddle Road" at an elevation of about 4,800 feet. There were a good number of *C. capitata* reared from both areas and along the Mauna Loa truck trail, the infestation in Jerusalem cherries decreased with elevation, as occurred in peaches on Maui.

Guavas collected from the higher elevations at which they are found on Maui, Hawaii, Molokai, Kauai, and Oahu produced a number of adults of *C. capitata,* while those collected at lower elevations seldom produced a single individual of this species. Guavas collected at elevations between 1,000 and 2,000 feet on Molokai and Lanai usually produced several *C. capitata* (table 3). Likewise, this fly commonly occurred in the guavas collected in the Kula-Ulupalakua area on Maui between 2,000 and 3,000 feet elevation and the Kona area of Hawaii between 1,500 and 2,500 feet.

Table 3. Summary of data obtained from collections of guavas from Lanai and Molokai in 1950, 1951, and 1952.

Date	No. coll.	No. puparia	No. puparia per fruit	Emergence		
				C. cap.	*D. dor.*	*Opius* spp.
			LANAI			
2-22-50	3	412	8.3	6	336	49
11-26-50	12	1,178	8.5	95	677	284
10-29-51	4	49	1.1	4	4	29
10- 3-52	6	221	1.8	69	61	64
			MOLOKAI			
2-21-50	4	575	9.6	183	351	18
11-26-50	3	346	3.4	33	142	73
3-28-51	3	349	4.0	29	147	112
10-22-51	4	299	3.9	0	75	212
9-23-52	4	103	1.3	10	11	47

Infestation at different seasons.

There is considerable evidence from both infestation data and the occurrence of adults in the field that *C. capitata* tends to increase during the late winter and spring months at the lower elevations where it occurs.

The data from coffee berries indicate that the infestation by *C. capitata* was lower from September to December than at other seasons. This period of lower infestation coincides with the period in which probably 75 per cent of the coffee berries are harvested at elevations below 1,600 feet but it does not coincide with the peak harvest at the 2,300 foot elevation which occurs during February, March, and April.

Infestation by Dacus dorsalis.

The data obtained from the studies on *C. capitata* have revealed much about the status of *D. dorsalis* at higher elevations. Since *D. dorsalis* has been suspected of affecting *C. capitata* adversely, it is considered pertinent to present some of the information obtained about *D. dorsalis* at these higher elevations.

From the peach collections made on Maui in 1949 it was found that several adults of *D. dorsalis* emerged per fruit from the collections at the lower elevations and that many of the collections above 3,100 feet failed to produce a single *D. dorsalis* adult. At elevations below 2,800 feet it caused considerable infestation but was scarce above 3,500 feet.

The data obtained from the coffee collected at the three different elevations (700, 1,200, and 2,300 feet) revealed that *D. dorsalis* was far more abundant in the collections from the 700 foot station than in those from the 2,300 foot station.

Similar trends in infestation associated with elevation have been indicated from the data obtained from the various fruits collected. There is no question that *D. dorsalis* is scarce at the higher elevations.

Ratio of Ceratitis capitata to Dacus dorsalis.

Many data are available which indicate that the ratio of *C. capitata* to *D. dorsalis* increased with elevation.

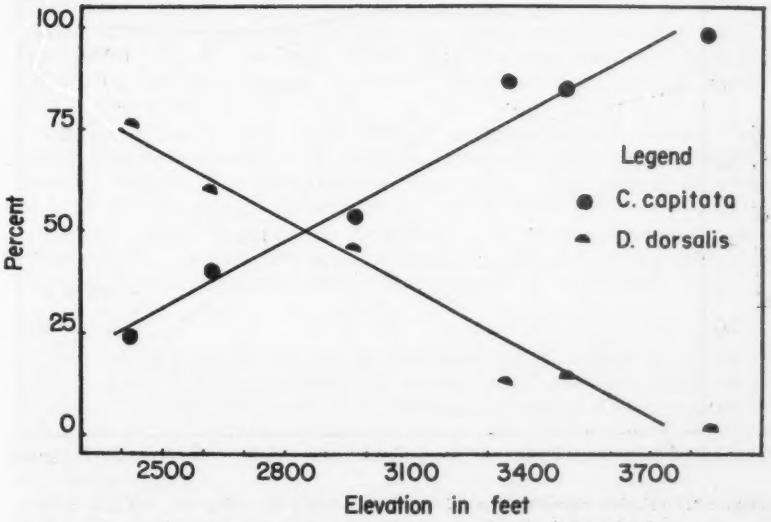

Figure 3. Relationship between *C. capitata* and *D. dorsalis* in peaches at different elevations on Maui, 1949 .

In the peach samples collected on Maui in 1949 there was a pronounced increase in the ratio of *C. capitata* to *D. dorsalis* with elevation as is shown in figure 3.

On a few of the farms where peaches were ripening over a period of several weeks during 1949 it was possible to obtain a number of successive collections throughout the period. The ratio of *C. capitata* to *D. dorsalis* on four of these farms located at different elevations is shown in figure 4. These curves not only show that the ratio of *C. capitata* to *D. dorsalis* increased with elevation, but also suggest that the ratio was probably higher in the spring and decreased as the season progressed.

A similar increase in the ratio of *C. capitata* to *D. dorsalis* with elevation occurred in the coffee collections (figure 5). In guavas collected near their upper limit or range, which is seldom above 2,000 feet, *C. capitata* was usually less abundant than *D. dorsalis,* but in a few instances *C. capitata* predominated.

Seven collections of loquats made in the Kula area on Maui in 1950 produced an average of 81 per cent *D. dorsalis* and 19 per cent *C. capitata.* A similar number of collections from the same area in 1951 produced an average of 76 per cent *D. dorsalis* and 24 per cent *C. capitata.*

Over 90 per cent of the flies obtained from Jerusalem cherries collected in the Volcano and Waikii areas on Hawaii were *C. capitata.*

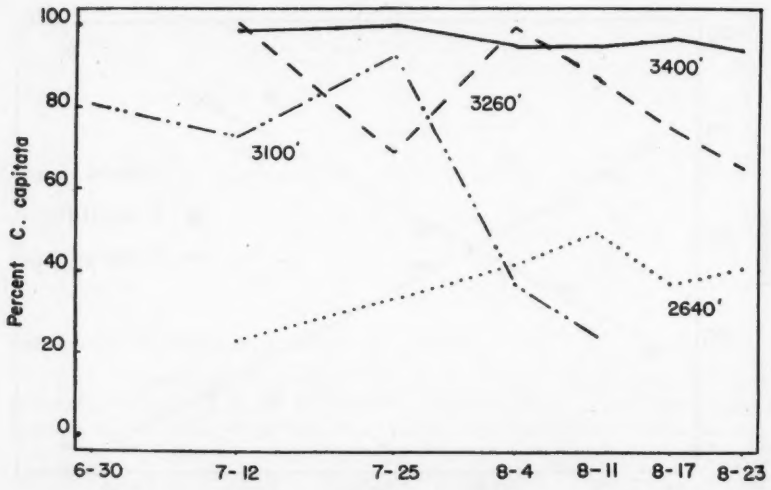

Figure 4. Relative abundance of *C. capitata* among the flies (*C. capitata* plus *D. dorsalis*) bred from peaches collected at different elevations on Maui, June-August, 1949. Each curve represents the percentage of *C. capitata* on a particular farm throughout the peach season.

Recent reduction in infestation.

During the past two to three years there has been a general reduction in the infestation by *C. capitata.*

The downward trend in infestation in peaches during the past three years is clearly indicated by the data in table 4, in guavas from higher elevations in table 3, and in coffee in figure 2. However, a large part of the decrease was due to the decrease in infestation by *D. dorsalis.*

Table 4. Summary of data obtained from collections of peaches on Maui in 1949, 1950, 1951, and 1952.

Date	No. coll.	No. of fruits	No. puparia	No. puparia per fruit	Emergence		
					C. cap.	*D. dor.*	*Opius* spp.
6/ 9-10/ 5/49	70	2,401	25,811	13.1	10,906	8,096	1,385
6/26- 7/28/50	12	578	5,594	9.7	3,525	457	552
7/23/51	12	338	1,324	3.9	699	0	102
9/25/52	3	146	468	3.2	257	0	135

Parasitization

The status of the several parasites that attack and successfully develop in *C. capitata,* like that of *C. capitata* and *D. dorsalis,* has changed during the past four years (Bess et al., 1950; van den Bosch, et al., 1951. These parasites can develop successfully in *C. capitata* (Clancy, 1952) and they have without doubt affected the status of both of these flies in Hawaii.

Since the maggots and puparia of *C. capitata* and *D. dorsalis* are extremely difficult to distinguish apart, the adult emergence data for *C. capitata, D. dorsalis* and their opiine parasites were used as a basis for calculating parasitization of both flies together and the relative abundance of the species involved.

The parasitization data obtained from the collections of various fruits at different elevations where *C. capitata* occurred (tables 2, 3, and 4, and figure 6) indicate that parasitization rose rapidly from 1949 to 1951 but in 1952 was not appreciably different from that in 1951.

There has been considerable parasitization in both peaches and coffee from collections which produced *D. dorsalis* adults, which indicates that *C. capitata* is being parasitized by the parasites of *D. dorsalis.*

Discussion

There was a great decrease in the abundance of *C. capitata* in the more tropical areas in Hawaii subsequent to the arival and establishment of *D. dorsalis* in 1946. However, it is doubtful that there was any great re-reduction in *C. capitata* at that time in the more temperate areas, even though *D. dorsalis* became abundant in these areas during the summer and fall months.

During the past five years *C. capitata* has been extremely scarce at lower elevations where it was once common in guavas, but the fly is still a pest of deciduous fruits, such as peaches and persimmons, at elevations between 2,000 and 5,000 feet. Since the decrease in the abundance of *C.*

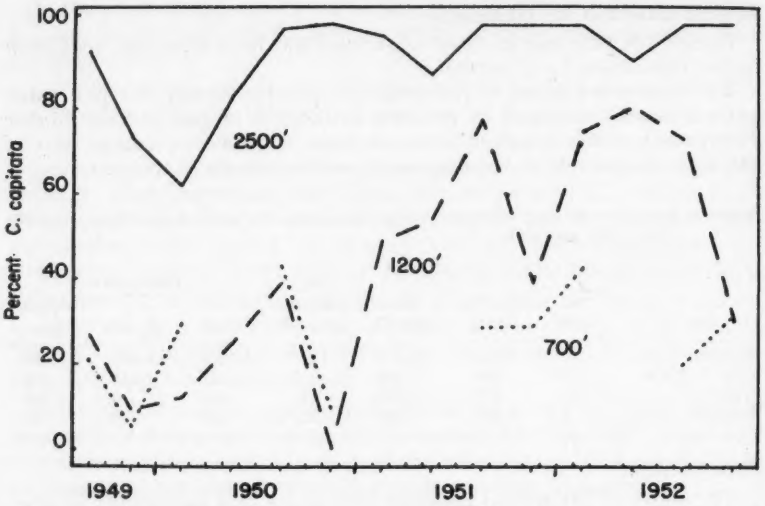

Figure 5. Relative abundance of *C. capitata* among the flies (*C. capitata* plus *D. dorsalis*) bred from coffee collected from three plantations at different elevations in Kona, Hawaii, August 1949 to December 1952.

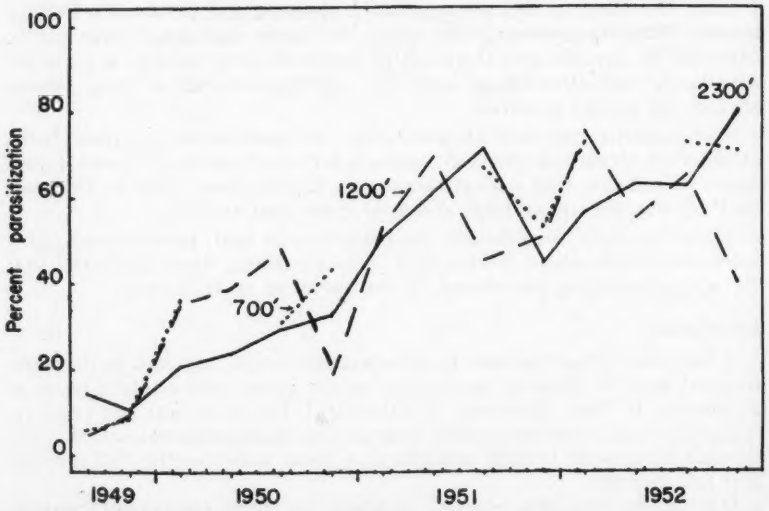

Figure 6. Parasitization of fruit flies (*C. capitata* plus *D. dorsalis*) in coffee collected from three plantations at different elevations in Kona, Hawaii, August 1949 to December 1952.

capitata in the more tropical lowland areas occurred following the introduction of *D. dorsalis,* it has been conjectured that the decrease was due in some way to the latter ffy. There are also reports that in Australia there are localities where *C. capitata* was once abundant but became scarce or absent subsequent to the establishment of *Dacus* (*Strumeta*) *tryoni* (Froggatt) in those localities.

The minimum average infestation by *C. capitata* in peaches for any year between 1916 and 1924 was 13.6 flies per fruit, and the average infestation for the period was 18.4 flies per fruit (Willard and Bissel, 1930). In comparison, the recent peach collections produced an average of only 4.5 *C. capitata* adults per fruit in 1949, 6.1 in 1950, 2.1 in 1951, and 1.8 in 1952. These data indicate that the *C. capitata* infestation in peaches is probably less now than it was 3 to 4 decades ago.

The infestation by *C. capitata* in guavas averaged 8.2 flies per fruit for the period 1916-24, and 4.9 for 1925-33 (Willard and Mason, 1937). However, during the past 4 years practically no *C. capitata* adults have emerged from the hundreds of guavas collected at lower elevations, and the average infestation for the collections made at all elevations was less than one *C. capitata* adult per 100 guavas.

There was apparently less change or reduction in infestation by *C. capitata* in coffee berries than in peaches or guavas. The average infestation for collections from Kona, Hawaii was 0.4 flies per berry for the period 1916-24, and 0.1 for 1925-33 (Willard and Mason, 1937).

Soon after its arrival, *D. dorsalis* increased to tremendous numbers and caused widespread serious damage to fruits, but fortunately its numbers and infestation during 1951 and 1952 were only a fraction of what they were in 1948 and 1949. It is still a pest in lowland areas but during the past two years it was extremely scarce in the more temperate areas where it was once a pest and *capitata* still causes damage. Possibly competition by *D. dorsalis* in some way caused the reduction of *C. capitata* to insignificant numbers in the more tropical areas soon after the establishment of *D. dorsalis* in 1946, but it is doubtful that the similar, more recent reduction of *D. dorsalis* in the more temperate areas was due to competition by *C. capitata.*

The peach collections from Maui produced an average of 3.4 *D. dorsalis* adults per fruit in 1949, 0.8 in 1950, and none in either 1951 or 1952. Since most of these peaches were collected above 2,000 feet elevation, and not a single *D. dorsalis* was reared from them during the past two years, apparently this fly has become of little or no economic importance at these higher elevations in peaches, even though it still infests guavas, mangoes, and other fruits at lower elevations. Furthermore, very few adults were seen during the past two years at these higher elevations where it was once abundant.

During the peak years of infestation by *D. dorsalis* in 1948 and 1949 many collections of guavas produced more than 100 adults of this fly per fruit but since 1950 the infestation has averaged less than 5 flies per fruit.

The combined infestation by both *C. capitata* and *D. dorsalis* in peaches was far less serious in 1951 and 1952 than in previous years. It also seems likely that the infestation by both flies in guavas during these last two years was less than was caused by *C. capitata* alone from 1916 to 1933.

It is evident that *C. capitata* has comprised a larger part of the population or infestation in coffee berries during the past several months, than it did during the earlier months of the period of study. This increase in the ratio of *C. capitata* to *D. dorsalis* was due to the reduced infestation by the latter, for actually the infestation by *C. capitata* also declined, especially at the 1,200 and 2,300 foot elevations in Kona.

Infestation data obtained from various fruits collected throughout the islands indicate that *D. dorsalis* is better adapted to the warmer climate at lower elevations than to the cooler climate at higher elevations, and that *C. capitata* is better adapted than *D. dorsalis* to conditions at higher elevations. However, as would be anticipated, the climate at 1,000 feet elevation in one area may be cooler than at 2,000 feet in another, and there are corresponding differences in the relative abundance of the two flies. These differences in the relative abundanc of *D. dorsalis* and *C. capitata* may be related in some way to differences in the behavior patterns of the flies, or possibly adult food supply, rather than to direct detrimental effects of the climatic factors themselves.

There has been considerable change in the status of the various introduced parasites and this should be considered if a clear picture of their activity is to be obtained. Their history may be briefly summarized as follows.

Soon after its release in 1913, *Opius humilis* Silvestri, increased rapidly in abundance and within a few months parasitized as high as 90 per cent of the larvae in coffee berries in certain localities. However, with the subsequent establishment and build-up of *Opius tryoni* (Cameron) and *Opius fullawayi* (Silvestri), *O. humilis* became scarce (Back and Pemberton 1918). Later Willard and Mason (1937) summarized the data obtained from 1914-1933 which indicate that *O. humilis* was the dominant parasite of *C. capitata* in coffee berries collected in Kona, Hawaii, during 1914-1917. In 1918 *O. tryoni* was the dominant species, and by 1922 this second species had been surpassed by the third species, *O. fullawayi*, which continued to be the dominant species from 1922 to 1929. However, from 1931 to 1933 *O. tryoni* was again the dominant parasite. During the period from 1922 to 1933 neither *O. tryoni* nor *O. fullawayi* actually became scarce, and both species have been recovered many times during the past 4 years. In contrast, no specimens of *O. humilis* have been reared from the numerous collections of fruits made between 1949 and 1952 in conjunction with the intensive studies of *D. dorsalis* parasites.

The change in status of the more recently introduced opiine parasites of *D. dorsalis* and *C. capitata* parallels to some extent the change in status of the parasites introduced in 1913 and 1914 to combat *C. capitata*. *Opius longicaudatus* (Ashmead) became well established and abundant in 1948 and 1949; by the latter part of 1949 *Opius vandenboschi* Full-

away had surpassed *O. longicaudatus* in abundance and in 1950 *Opius oophilus* Fullaway became by far the most abundant parasite of D. *dorsalis* on Oahu (Bess, et al., 1950; van den Bosch, et al., 1951). The following year the latter parasite also became the dominant species on the outer islands.

These data show that there was not only a rapid increase of *C. capitata* and *D. dorsalis* following their introduction but there was a similar rapid increase of the six opiine parasites following their introduction. Furthermore, the two flies and 6 parasites are now less abundant in Hawaii than they were during the first 3 years after their introduction.

Many similar examples of rapid increase have occurred following the introduction of both injurious and beneficial species into new areas where they became successful. Clausen (1951) concluded that, "A *fully effective* parasite or predator is always easily and quickly established." Perhaps it is equally true that species destined to become pests have also been easily and quickly established.

Parasites have apparently been no more effective on *D. dorsalis* in the more temperate areas of the high elevations than in the more tropical lowland areas. The scarcity of *D. dorsalis* in these temperate areas is probably closely associated with its reduced abundance in the more tropical areas from which it spread in great numbers during the period in which it was tremendously abundant.

The reduced abundance of both *D. dorsalis* and *C. capitata* during the past three years has been directly related to increased parasitization. Since the egg-larval parasite, *O. oophilus,* became numerous the infestation has been much lower throughout the islands than it was previously. Furthermore the amplitude of the oscillations in infestation has been greatly reduced and the level of infestation has become at least for the present stabilized at a much lower level.

Summary

Both *C. capitata* and *D. dorsalis* developed successfully together in individual fruits and the larvae of one species apparently caused no reduction in the number of adults of the other species produced in those fruits.

In the more tropical lowland areas *D. dorsalis* was more abundant than *C. capitata,* and in the more temperate upland areas the latter species was more abundant. At elevations around 500 to 1000 feet *C. capitata* tended to become more abundant in late winter and spring and *D. dorsalis* more abundant during the fall.

The infestation by both flies during 1951 and 1952 was apparently lower than the infestation by *C. capitata* alone prior to the arrival of *D. dorsalis.*

Parasitization has averaged well above 50 per cent for many months. Furthermore, the *D. dorsalis* parasites appear to be attacking *C. capitata* in coffee berries about as readily as they attack *D. dorsalis.* Undoubtedly

these parasites, especially the egg-larval parasite, *O. oophilus,* which has continued to parasitize a high percentage of the population at these lower population levels, have been one of the main factors in the reduction of the fly infestation.

LITERATURE CITED

Back, E. A. and **C. E. Pemberton.** 1918. The Mediterranean fruit fly in Hawaii. U. S. Dept. Agr. Bul. 536, 119 pp., 21 pls., 24 figs.

Bess, H. A., Robert van den Bosch, and **Frank Haramoto.** 1950. Progress and status of two recently introduced parasites of the oriental fruit fly, *Dacus dorsalis* Hendel, in Hawaii. Proceedings Hawaiian Entomological Society 14 (1) :29-33.

Clausen, C. P. 1951. The time factor in biological control. Jour. Econ. Ent. 44(1):1-9.

van den Bosch, Robert, H. A. Bess, and **F. H. Haramoto.** 1951. Status of oriental fruit fly parasites in Hawaii. Jour. Econ. Ent. 44(5):753-759.

Willard, H. F. and **T. L. Bissel.** 1930. Parasitism of the Mediterranean fruit fly in Hawaii 1922-1924. U.S.D.A. Cir. 109:1-12.

Willard, H. F. and **A. C. Mason.** 1937. Parasitization of the Mediterranean fruit fly in Hawaii, 1914-33. U.S.D.A. Cir. 439, 18 pp.

Description and Characteristics of a Granulosis Virus of the Imported Cabbageworm[1, 2]

By YOSHINORI TANADA

UNIVERSITY OF HAWAII AGRICULTURAL EXPERIMENT STATION, HONOLULU, AND UNIVERSITY OF CALIFORNIA, BERKELEY

There are several early records of virus diseases in the imported cabbageworm, *Pieris rapae* (L.), but prior to 1951, none of these records presented positive evidence that the disease concerned was caused by a virus. In 1886, Forbes attempted to transmit to the imported cabbageworm bacteria obtained from silkworms which had died of jaundice. In some of the infected cabbageworms, he noted large spheres or "mulberry granules," from 2 to 4 microns in diameter, occurring singly and in masses. He pointed out the similarity of the "mulberry granules" to structures present in silkworms infected with jaundice. The structures that Forbes called "mulberry granules" might have been virus polyhedra. Pospelov and Noreiko (1929) concluded that a yeast, *Debaryomyces tyrocola* Kon., contained virus and caused diseases in certain lepidopterous species, but their attempt to infect the larvae of *Pieris rapae* was inconclusive.

The early records of bacterial diseases in *Pieris rapae* reported by some workers (Forbes 1886, Wilson, Pickett, and Gentner 1919, Brown 1930, Moss 1933) are probably not all correct and the diseases may have been caused by a virus. Glaser (1928), Sweetman (1936), Bergold (1943), and Steinhaus (1946, 1949*a*) listed *Pieris rapae* among the insects attacked by virus diseases. In 1940, Richards observed many larvae of *Pieris rapae* killed in the laboratory by a "wilt" disease. He suggested that "wilt" was present in the larvae in a dormant condition and that it became evident when the larvae were kept in captivity. In Hawaii,[3] Holdaway and Lucas (1941) suspected the "wilt" disease of *Pieris rapae* to be viral in nature. The disease was responsible for a high mortality of cabbageworms in the field, particularly at elevations of less than 1,000 feet.

The first actual demonstration of a virus disease in the imported cabbageworm was presented by Thompson in 1951. He found a granulosis virus infection in the larvae of the second generation stock which was originally started from a field-collected adult female. As will be mentioned later in this paper, larvae of *Pieris rapae* collected from Colorado and Hawaii were found infected with granulosis viruses. These viruses are apparently the same as that found by Thompson.

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[1] Portion of the thesis submitted as a partial fulfillment for the degree of Doctor of Philosophy from the University of California, Berkeley.

[2] Approved by the Director of the Hawaii Agricultural Experiment Station as Technical Paper No. 284.

[3] The writer, while undertaking a research study at the University of Hawaii in 1940, noticed many of the imported cabbageworms dying in the rearing jars. The symptoms of the infected larvae were similar to those of the granulosis described in this paper.

Another virus disease, a polyhedrosis, was observed by the writer in laboratory-reared imported cabbageworms. This virus disease was found to be the same as the polyhedrosis of the alfalfa caterpillar, *Colias philodice eurytheme* Boisd.[4]

EXPERIMENTAL PROCEDURE

The present study was conducted at the Laboratory of Insect Pathology, University of California in Berkeley.

The cabbageworms were reared in a laboratory located in Albany, California. The daily temperature of the laboratory fluctuated mainly between 21 to 26° C with occasional extremes of 17 and 30° C. The daily relative humidity ordinarily ranged from 50 to 60 per cent, but occasionally dropped to 18 per cent or rose to 74 per cent.

In general, the cabbageworms were reared from eggs laid by field-collected adults which were enclosed in a cloth cage with a glass top. During the winter months, the eggs were obtained from butterflies reared in the laboratory. The adults laid their eggs on a young potted kale plant which was replaced with a fresh one on alternate days. By this method, larvae of uniform size and age were obtained.

The eggs, together with the leaves on which they were laid, were "disinfected" by immersing for 90 minutes in a solution of 10 per cent formaldehyde (by weight) and then washing in running tapwater for about 15 minutes to remove the formaldehyde (see Thompson and Steinhaus 1950). The "disinfected" eggs were placed in sterile half-pint cardboard containers with a vial containing a mustard or a kale leaf. The container was covered with a half of a sterile petri dish. When the larvae were in the second instar, they were placed, two each, in sterile containers in which they were reared until they reached the proper size.

The food of the cabbageworms varied with the availability of the cruciferous plants. The chicken, or thousand-headed, kale, *Brassica oleracea* var. *acephala* DC. and two species of wild mustard were used. A smooth leaved mustard, *B. campestris* L., was preferred by the cabbageworm to the rugose leaved *B. Kaber* (DC.) Wheeler (=*B. arvensis* sensu Rabenh.).[5]

Other insect species which were used in the experiments were kindly supplied by Dr. C. G. Thompson either as eggs or very young larvae. All of these species were fed alfalfa, *Medicago sativa* L., or bur clover, *M. hispida* Gaertn.

The larvae were infected orally and no inoculations into the body cavity were attempted as such a path of infection by pathogens is probably rare in nature and would give a much higher percentage of infection. In general, the pathogenic inoculum was prepared by macerating a fifth instar larva, which had died of granulosis, in a sterile mortar and suspending the macerated contents in about 25 to 50 ml of a 0.2 per cent blood albumin solution. The larvae to be infected were fed leaves dipped into this solution. About 10 to 20 larvae, generally in their fourth instar

[4] The results of the study with the polyhedrosis virus of the imported cabbageworm are being prepared for publication.

[5] The scientific names of the plants are from Abrams (1940) and Bailey (1949).

were used for each treatment. In both the treated and control groups, the larvae were reared individually in sterile containers. Larvae that died were dissected and the body contents examined under the microscope to determine the nature of the pathogen.

For the histopathological study, the larvae were fixed in alcoholic Bouin's solution (Duboscq-Brasil's modification) and prepared for sectioning by dehydration through a methyl benzoate and benzene series and thence into paraffin (see Romeis 1948).

The virus specimens for electron microscopy were prepared and shadowed with palladium according to the technique described by Steinhaus, Hughes, and Wasser (1949). The virus was observed through the RCA electron microscope, type EMU-2B. The size of the specimens was calculated from polystyrene particles that were 260 millimicrons in diameter.

SYMPTOMS AND PATHOLOGY

The granulosis virus, which was discovered by Thompson (1951) in laboratory-reared larvae of *Pieris rapae*, was forwarded to the writer for description and identification. Although Thompson was not able to establish whether the disease occurred in nature, field-collected imported cabbageworms received from Hawaii and Fort Collins, Colorado[6] were also found infected with granulosis. The investigation of the granulosis disease of *Pieris rapae* was conducted mainly with the infectious material obtained from Hawaii.

The imported cabbageworm showed the first signs of infection in about 3 to 5 days after feeding on a leaf that had been dipped in a virus suspension. As the infection advanced, the larva became progressively paler than normal larva. Just prior to death, the larva appeared greenish to milky yellow on the dorsal and lateral surfaces while the ventral surface was almost white. Sometimes the integument was mottled and shiny. The body was often slightly bloated yet soft. At this stage, there was little feeding and the larva was languid. Soon after death, the body rapidly darkened until it was entirely black. There was a marked liquefaction of the internal tissues. Unlike most granuloses of other insect species (Steinhaus 1947, Steinhaus and Thompson 1949), the integument was very fragile and in this respect resembled a polyhedrosis infection. The dead or dying larva often remained suspended from a leaf or the side of the container by its abdominal or caudal prolegs (Fig. 1A). At death the larva was in a wilted condition. When the fluid content of the wilted larva was examined under the microscope, it had a brownish tint because of the numerous granules it contained.

Occasionally a larva died without becoming chlorotic. Such larvae often showed signs of having had diarrhea as indicated by their "dirty" terminal segment and by the tendency to adhere to the substratum by their anal region. Some vomited fluid from the mouth. Although the body was soft, the integument was not easily torn. Since the blood con-

[6] Dr. T. O. Thatcher, assistant entomologist at Colorado Agricultural and Mechanical College, sent the specimens from Colorado to Dr. E. A. Steinhaus, associate entomologist at University of California, who forwarded them to the writer.

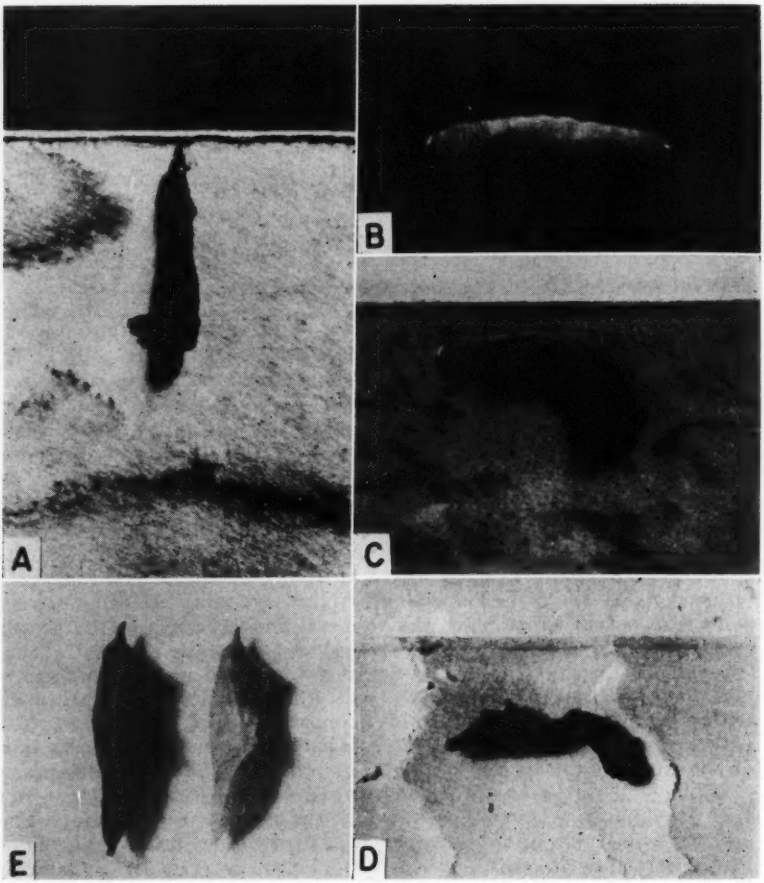

Fig. 1. Imported cabbageworm, *Pieris rapae* (L.), infected with granulosis virus. **A.** Larva, which died of granulosis, hanging by its caudal prolegs from the side of the rearing container. **B.** Normal prepupa. **C.** Early stage of an abnormal prepupa, which is caused by high temperature or infectious disease. **D.** Abnormal prepupa beginning to shrivel to a dry scale. **E.** Normal pupa on the right; infected pupa, which has darkened, on the left.

tained many bacteria as well as granules, such cases apparently resulted from a mixed infection of virus and bacteria.

If the infected larva survived to the prepupal stage, it might die as an abnormal prepupa (Fig. 1C, D) which later darkened and dried up. If the infected larva pupated, it might turn black and die (Fig. 1E). The internal contents of dead prepupae and pupae were brownish and fluid.

Thompson (1951) reported that the larva died within 7 to 8 days after infection. As indicated by the results of the tests described later, this period might vary with the temperature, the age of the larva, the concentration and virulence of the virus inoculum, and the secondary invasion by bacteria. But death, in general, occurred within 4 to 8 days after infection with an occasional larva dying as early as 48 hours or as late as 12 to 15 days.

The gross internal pathology in *Pieris rapae* resembled that of other granuloses (Paillot 1926, Steinhaus 1947, Steinhaus and Thompson 1949, Steinhaus, Hughes, and Wasser 1949, Hughes and Thompson 1951). The blood of infected larvae turned from a clear to cloudy green during the late stage of infection. At death, it became turbid and milky or slightly brownish. When examined under the microscope, abundant minute granules were seen in active Brownian movement in the blood. Some granules were found moving actively within spherical vesicles. Similar vesicles were also observed in other granuloses (Paillot 1937, Bergold 1948*a*, Hughes and Thompson 1951).

The fat tissue had an opaque white appearance with minute specks of cloudy areas, as compared with the translucent whitish fat bodies of normal larvae. In a late infection, the anterior and posterior ends of the mid-gut were tinged with brown. The cause of the discoloration might not be entirely due to the lack of food in the mid-gut. The hypodermis of an infected larva tended to peel off from the cuticle much more easily than that of a healthy larva.

Microscopic sections of larvae in three different stages of infection were examined: first, an early stage, 3 days after ingesting the virus; second, a late stage, 5 days after ingesting the virus; third, just after death. Pathologic changes were apparent in the fat and hypodermal tissues only. In many cases of granuloses reported so far, the fat tissue alone had shown signs of pathology (Steinhaus 1947, Steinhaus, Hughes, and Wasser 1949, Hughes and Thompson 1951). Other granuloses affecting the hypodermis as well as the fat tissue were reported for the two viruses of *Euxoa segetum* Schiff. (Paillot 1935, 1936, 1937, 1943) and for that of *Pieris brassicae* (Paillot 1926). In the buckeye caterpillar, *Junonia coenia* Hübner, Steinhaus and Thompson (1949) observed that the principal tissue affected was the fat tissue, but at times other tissues, such as the hypodermis and the tracheal matrix, were also involved.

Since the process of necrobiosis in the fat and hypodermal cells was essentially the same, the pathologic changes in both tissues will be described together. The nuclei of normal fat and hypodermal cells were oval or spherical in outline, rather small, and contained one or more nucleoli (Fig. 2A). At an early stage of infection, the nuclear material,

especially the nucleolus, seemed to break up and condense into irregular masses. Pycnotic nuclei with condensed chromatin material in the center or to one side were common in both the fat and the hypodermis (Fig. 2B). Sometimes the dark-staining nuclear material might form a continuous or partial ring near the nuclear membrane. The areas between the nuclear membrane and the dark-staining nuclear material were filled with a homogenous light-staining material, probably the granules. As the disease progressed, the nucleus continued to hypertrophy, and the nuclear membrane became barely visible. There was apparently a decrease in chromatin material. Meanwhile the entire cell increased in size. At a late stage, the boundary between the nucleus and cytoplasm disappeared, either as a result of the nucleus occupying the entire cell or, more probably, because the nuclear membrane had disintegrated and the nuclear and cytoplasmic elements had intermingled (Fig. 2C).

In a fat cell, the number of fat globules decreased as the disease progressed. Not all the cells in a fat body were affected uniformly. Some of them might be in an advanced stage of infection while others showed only slight signs of change. The progress of infection among the hypodermal cells tended to be more uniform than among the fat cells.

Different workers hold different opinions as to whether the granules multiply in the nucleus or the cytoplasm. Paillot (1926) stated that the multiplication of the virus he studied took place in the cytoplasm of fat and hypodermal cells of *Pieris brassicae*. In 1936, he reported that in one of the virus diseases of *Euxoa segetum* the granules appeared first in the cytoplasm, while in another disease, the granules multiplied especially in the nucleus and also in the cytoplasm. Later he found a third granulosis in the same species in which the granules multiplied in the nucleus (Paillot 1937). In *Peridroma margaritosa* (Haworth), Steinhaus (1947) observed large numbers of the granular inclusion bodies in the cytoplasm. This observation was repeated in 1949 (Steinhaus, Hughes, and Wasser). Bergold (1948*a*) found the granules in the cytoplasm of infected blood cells of *Cacoecia murinana* Hübner. In 1949, Steinhaus and Thompson stated that the granules in *Junonia coenia* possibly originated within the nucleus and sooner or later accumulated in the cytoplasm or fat cells. In *Sabulodes caberata* Guenée, Hughes and Thompson (1951) observed that the granules appeared in the nucleus rather than in the cytoplasm of fat cells. They suggested that some reports of granules arising in the cytoplasm may have resulted from observations made after the infection had progressed too far to distinguish between nucleus and cytoplasm. In the present instance the granules appeared to develop in the nucleus of the cells of *Pieris rapae*.

Fig. 2. Histological sections through the hypodermal tissue of the imported cabbageworm, *Pieris rapae* (L.), showing progressive stages in the infection with granulosis. **A.** Healthy hypodermal cells. **B.** Hypodermis in early stage of infection; nuclei enlarged and pycnotic. **C.** Hypodermis in late stage of infection; the hypertrophied nuclei are breaking down. Tissues stained with iron hematoxylin and eosin. Magnification of A, B, and C approximately the same.

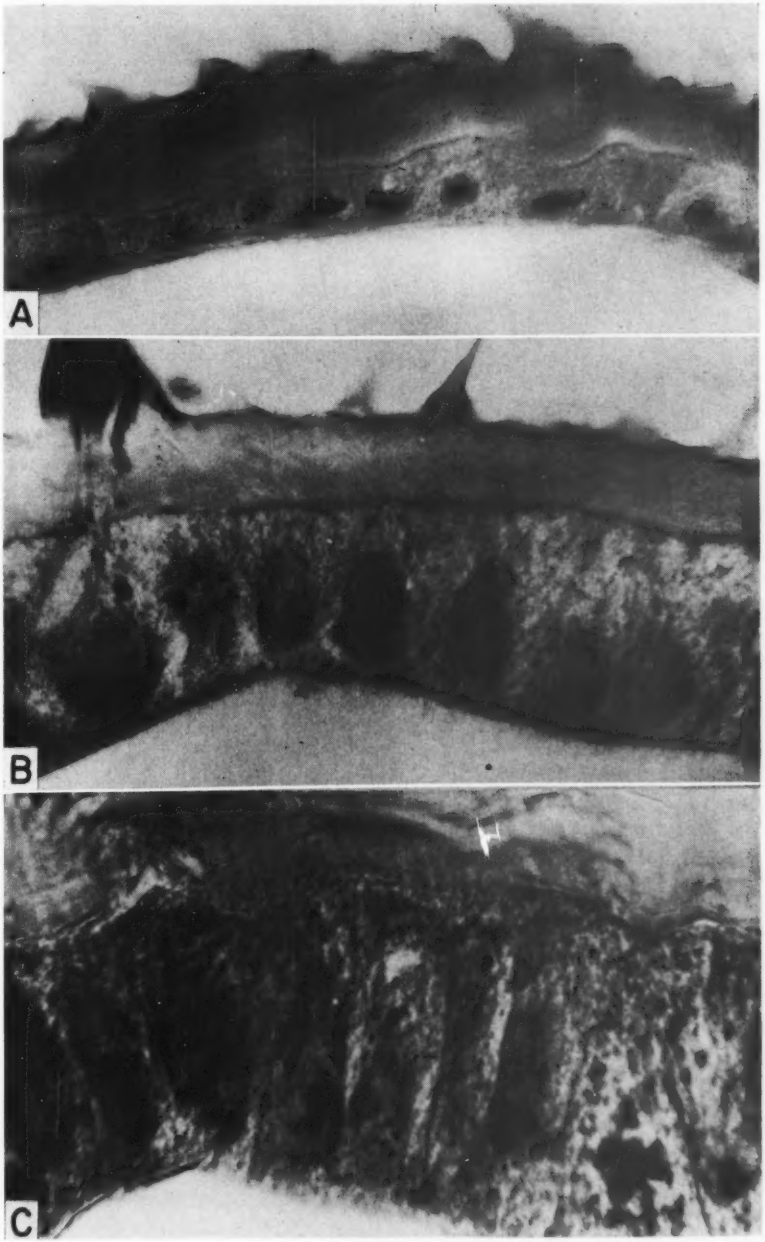

Figure 2.

THE CAUSATIVE AGENT

Bergoldia virulenta, new species

Morphology

The granules were obtained from the blood of a larva in the late stage of infection or by grinding in a mortar several larvae which had died of granulosis. The granules from the macerated larvae were concentrated by repeated centrifugation and washing in sterile distilled water. A drop of the infected blood or of the concentrated granules was then dried on an electron microscope screen.

Under the electron microscope, the granules were oval in outline and resembled those described for other granuloses (Fig. 3A). They had an average size of about 0.2 by 0.3 microns. Some very elongate ones and also other bizarre forms were present. These appeard to have resulted from the fusion of several granules. Occasionally free virus particles were present.

When the dried granules on the screen were treated for 10 minutes with 0.01 M sodium hydroxide and the alkali washed off by dipping the screen in distilled water, the granules appeared partially dissolved, revealing the single rod-shaped virus particle within (Fig. 3B). For the complete liberation of the virus particle from the granular matrix, about 2 ml of a thick suspension of granules, that had been purified by repeated centrifugation, were treated for about 2½ hours with 10 to 20 ml of a mixture of equal parts of 0.1 M sodium chloride and 0.1 M sodium carbonate. The entire mixture was centrifuged for 15 minutes at about 5,000 rpm to remove the coarse undissolved particles. The liberated virus particles in the supernatant fluid were washed and concentrated by two or more centrifugations at 13,000 rpm (20,000 g) for about an hour. A drop of the final sediment was mounted on an electron microscope screen.

Under the electron microscope, many of the free virus particles were straight rods, but some were curved. They varied greatly in size. In 286 particles examined, the width ranged from 41 to 100 millimicrons, while the length ranged from 221 to 290 millimicrons. Most of the virus particles ranged within 61 to 90 millimicrons by 231 to 270 millimicrons. Apparently these fairly thick virus rods were enclosed in a membrane which has been called the "spherical membrane" by Bergold (1950).

In one sample that was treated with alkali for 5 hours instead of 2½ hours, the virus particles were not only distinctly thinner, but some of the particles had the spherical membranes attached to them (Fig. 3C). Occasionally what appeared to be empty collapsed membranes could be seen. The size of these naked particles ranged from 31 to 60 millimicrons

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Fig. 3. Electron micrographs of granules and virus particles. **A.** Untreated granules. **B.** Granules treated with alkali, showing the single rod-shaped virus particle within the dissolved matrix. The white spheres are polystyrene particles of 260 millimicrons in diameter. **C.** Virus particles within "spherical membranes" and naked virus particles. Observe the empty tubular membrane near the center of figure. Approximate magnifications: A–27,600 ×; B–21,000 ×; C–25,100 ×.

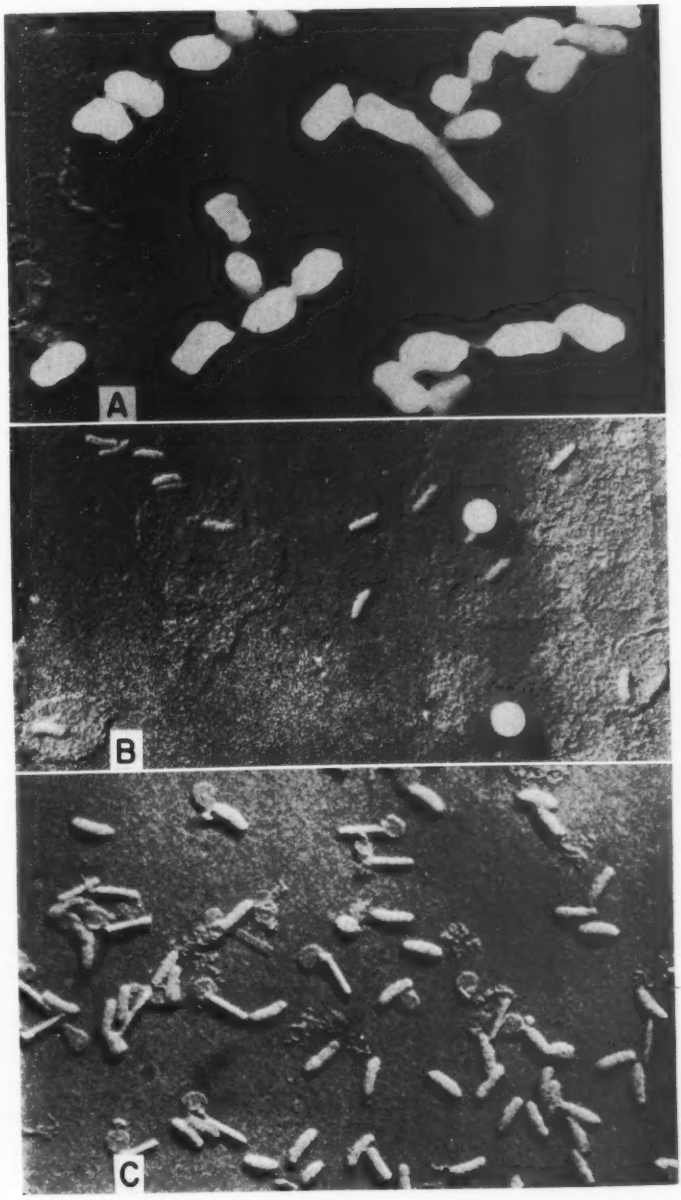

Figure 3.

in width and 191 to 340 millimicrons in length, with most of them being 41 to 50 millimicrons by 291 to 300 millimicrons. Since the virus rods were often curved within the spherical membrane, the apparent greater length of the naked virus rods might have resulted from their straightening out after emerging from the membrane. However, the difference might also be caused by the variations present between the samples.

Besides the rod-shaped particles, roughly spherical bodies were sometimes seen in virus preparations and may represent the initial forms described by Bergold (1950). In some cases, the rods were folded in the middle and surrounded by a membrane as reported by other workers (Bergold 1950, Hughes and Thompson 1951, Wasser and Steinhaus 1951, Hughes 1952).

Cross Infectivity Study

The infectivity of the granulosis viruses reported from the following insects was tested on the cabbageworm: *Natada nararia* Moore, *Amelia pallorana* (Robinson), *Sabulodes caberata* Guenée, *Estigmene acraea* (Drury), *Junonia coenia* Hübner, *Peridroma margaritosa* (Haworth), *Harrisina brillians* Barnes & McDunnough, and *Argyrotaenia velutinana* (Walker). About 15 to 20 cabbageworms were used for each test. None of the viruses caused a typical granulosis in *Pieris rapae*. In some of the treatments, 1 to 3 larvae died from bacterial infection.

Since living specimens of all the above insect species could not be obtained, the granulosis virus of *Pieris rapae* was fed only to *P. margaritosa, S. caberata,* and *E. acraea*. In each case, the inoculum was tested by feeding it to five cabbageworms. All the treated cabbageworms died of granulosis but the untreated controls survived to adulthood, indicating that each virus inoculum was highly infectious. None of the 10 to 20 larvae of the other insect species which were fed the virus died of granulosis. Some, however, died from bacterial infection. Thompson (1951) reported that the granulosis virus of *Pieris rapae* was not infectious to *P. margaritosa, J. coenia,* and *S. caberata,* and that he was not able to infect the cabbageworm with viruses from these other species.

Identification of the Virus

As the cross-infectivity tests with most of the other insect species in California which are infected with granulosis have not succeeded, the virus of *Pieris rapae* is heretofore undescribed. The presence of the granular matrix around the virus particle places the virus in the genus *Bergoldia* established by Steinhaus (1949*a*, *b*). The name, *Bergoldia virulenta* n. sp., is proposed for the virus. The specific name *virulenta* is derived from the Latin, *virulentus,* meaning full of poison or poisonous. Specimens of the virus have been sent to the American Type Culture Collection.

The granulosis virus of *Pieris rapae* resembles that of the pseudograsserie of *Pieris brassicae* which is caused by *Bergoldia brassicae* (Paillot) (Paillot 1926). Both virus diseases exhibit approximately the same symptoms in the host larvae and their histopathology is similar, al-

though Paillot claimed that the virus of *Pieris brassicae* originated in the cytoplasm, whereas that of *Pieris rapae* appeared to develop in the nucleus. Until a study of the transmission of the viruses to the two host species is undertaken, the identity of these two virus diseases cannot be established with certainty.

Distribution

As mentioned previously, the granulosis of the imported cabbageworm has been found in three different localities, California, Colorado, and Hawaii. The viruses from the three localities were compared to see if they were identical. A preliminary test using 10 to 15 cabbageworms for each treatment indicated that they were all highly virulent, produced identical symptoms in infected larvae, and that the period of infection[7] was the same.

The test was repeated using dried and moist viruses. The dried virus was prepared by grinding the body of a larva which had died of granulosis with 1 to 2 ml of sterile distilled water and drying the suspension at 34° C for 48 hours. The dried material was resuspended in 50 ml of 0.2 per cent blood albumin solution. The moist virus inoculum was prepared by grinding a larva which had recently died and diluting with 50 ml of 0.2 per cent blood albumin solution just before treatment. Each treatment and the control contained 10 fourth instar larvae. The results confirmed the preliminary observations. In the group infected with moist virus inoculum, the virus from Hawaii killed the larvae in 3 to 5 days, that from California in 4 to 5 days, and that from Colorado in 3 to 6 days. The group infected with the suspension of dried virus died in about the same period.

The granules and the free virus particles of the granuloses from California and Colorado have approximately the same size range as those of the granulosis from Hawaii. In one sample of the granulosis from California, however, the virus particles, still enclosed in the spherical membrane, were much shorter than any of the other samples from California and also smaller than those from Hawaii and Colorado. Since these smaller virus particles showed little variation in size, only 20 of them were measured. They ranged in width from 40 to 52 millimicrons and in length from 173 to 196 millimicrons. Although they appeared to be more curved than the other particles, the curvature alone could not have caused the great reduction in length as compared to the other samples. Probably the virus particles were still in the elongating stage as described by Bergold (1950).

Effect of Desiccation

In the previous study, the virus appeared to have lost little if any of its virulence through drying for a short period. The effect of more prolonged drying was investigated, for if the virus can withstand a long period of dryness it would be more useful in the biological control of

[7] The period of infection may be defined as the interval from the time the host feeds on the pathogen until the death of the host from a frank infection.

Pieris rapae. In this study the inoculum was prepared from a fifth instar larva which had died of granulosis. The larva was ground in a sterile mortar and diluted with 50 ml of sterile distilled water. Ten drops of the solution were placed on sterile glass slides and dried overnight. The dried slides were stored in the dark at room temperature. At the time of testing, the virus smear on one slide was washed off into a sterile beaker with 25 ml of 0.2 per cent blood albumin solution. A sterilized forceps was used to scrape the virus smear off the slide.

After 36 days of drying the virus, when fed to 14 larvae, killed all of them. All the control larvae developed into butterflies. When dried for 168 days, the virus killed eight of the 10 treated larvae and two developed into adults. Five of the eight infected individuals died as larvae, while three died as pupae. In the control group, nine larvae reached the adult stage and one died from an amicrobic cause. The granulosis virus, therefore, appeared capable of withstanding desiccation in the dark at room temperature for several months, but after 5½ months, it seemed to lose some of its virulence. The polyhedrosis virus has been reported to withstand desiccation for 2 years (Glaser 1928, Thompson and Steinhaus 1950).

Effect of Temperature

Temperature is known to affect the virulence of insect viruses. In 1917, White found that the virus of sacbrood in a water suspension was inactivated when heated to 59° C for 10 minutes. In honey, it was inactivated when heated to 70° C for 10 minutes. Glaser (1928) stated that the polyhedrosis virus lost its virulence when held at 60° C for 15 to 20 minutes. In a later publication, Glaser and Lacaillade (1934) modified their statement and stated that the polyhedrosis virus was not always destroyed when heated for one-half to one hour at 60° C. It was inactivated, however, at 100° C for one-half hour. Bergold (1943) reported that boiling for 10 minutes inactivated the polyhedra.

The effect of low temperature on *Bergoldia virulenta* was investigated first. Virus material stored at 4 to 6° C in the refrigerator did not show any noticeable loss in virulence even after storage for over a year. When stored for 36 days in a frozen condition in a deep freeze refrigerator regulated at −32° C, the virulence of the virus was hardly affected. The larvae, which were fed virus frozen for 10 days, died in 4 to 6 days as compared to 5 to 7 days for those fed virus kept frozen 36 days.

The inactivation of *Bergoldia virulenta* by high temperature was determined at the thermal inactivation point and the thermal inactivation time. In a preliminary test, the thermal inactivation point was determined with virus inoculum which was heated in tightly stoppered vials. The vials were heated completely immersed in a water bath for 10 minutes at the following temperatures: 45, 55, 60, 65, 70, and 75° C. The heat-treated virus inoculum was fed to fourth instar cabbageworms. The thermal inactivation point occurred between 70 and 75° C for 10 minutes of heating period.

PER CENT MORTALITY

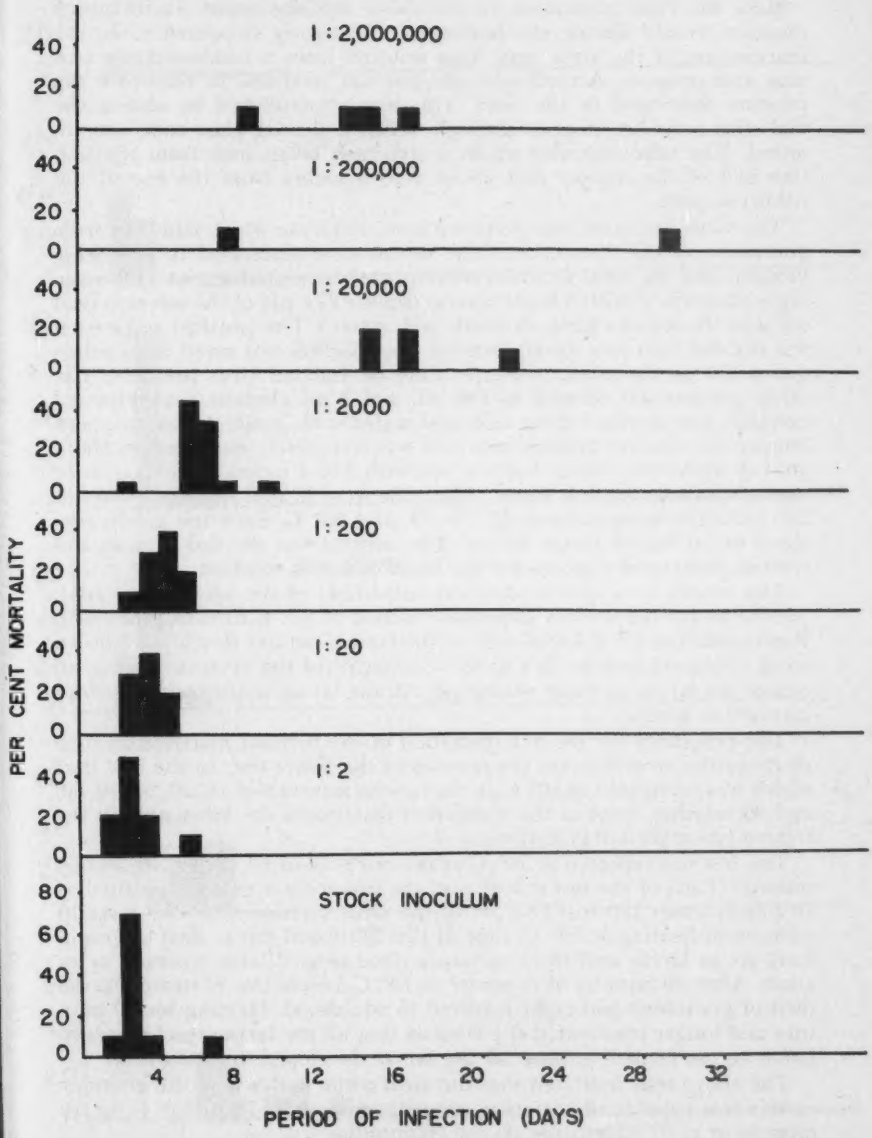

Fig. 4. Effect of different concentrations of the virus inoculum on the period of infection of *Bergoldia virulenta* n. sp. in *Pieris rapae* (L.).

Since the virus suspension in the above test was under an unknown pressure created during the heating of the tightly stoppered vials, the inactivation of the virus may have resulted from a combined effect of heat and pressure. Accordingly, the test was modified to eliminate the pressure developed in the vials. This was accomplished by sealing the vial with a rubber stopper through which a slender glass tube was inserted. The tube extended about a sixteenth of an inch from the bottom end of the stopper and about 4 to 5 inches from the top of the rubber stopper.

The virus inoculum was prepared from 10 larvae which had died from granulosis in the fifth instar. The larvae were macerated in a Waring blender, and the virus granules concentrated by centrifugation and washing with sterile distilled water several times. (The pH of the solution read 5.9 with Beckman's glass electrode pH meter.) The purified suspension was divided into two equal portions. One portion was saved for a subsequent test on the effect of temperature on isolated virus particles. The other portion was diluted to 100 ml, and 3 ml aliquots were pipetted carefully into sterile 1 dram vials and sealed with sterile rubber stoppers. During the heating process, each vial was completely immersed to about an inch above the rubber stopper, but with 3 or 4 inches of the glass tube extended above the hot water. The vials were heated for 10 minutes at the following temperatures: 65, 70, 75, and 80° C. Each test group consisted of 10 fourth instar larvae. The control was divided into an untreated group and a group fed the blood albumin solution.

The results were nearly identical with those of the preliminary trial. All the larvae fed a virus suspension heated at 65° C died of granulosis. Virus heated at 70° C killed nine of the larvae, but one developed into an adult. Temperatures of 75 and 80° C inactivated the virus sufficiently to enable the larvae to reach adulthood. All the larvae in the control groups matured to adults.

The procedure for the determination of the thermal inactivation time of *Bergoldia virulenta* was the same as in the above test. In the first trial which was conducted at 60° C at the various intervals of 10, 20, 30, 40, 60, and 90 minutes, none of the treatments inactivated the virus, and all the treated larvae died of granulosis.

The test was repeated at 70° C at the intervals of 10, 20, 30, 40, and 60 minutes. Each of the test groups and the two control groups consisted of 10 fourth instar larvae. (The pH of the virus solution was 5.9.) After 10 minutes of heating at 70° C, nine of the 10 treated larvae died of granulosis, six as larvae and three as pupae. One treated larva emerged as an adult. After 20 minutes of exposure to 70° C, two of the 10 treated larvae died of granulosis and eight matured to adulthood. Heating for 30 minutes and longer inactivated the virus so that all the larvae reached adulthood. In the control groups, all the larvae developed into adults.

The above tests indicated that the virus while enclosed in the granular matrix was capable of surviving temperatures up to 70 to 75° C for 10 minutes or at 70° C between 20 and 30 minutes.

Another test was conducted to determine the effect of temperature on the free virus particles. One-half of the purified granules that were used

PER CENT MORTALITY

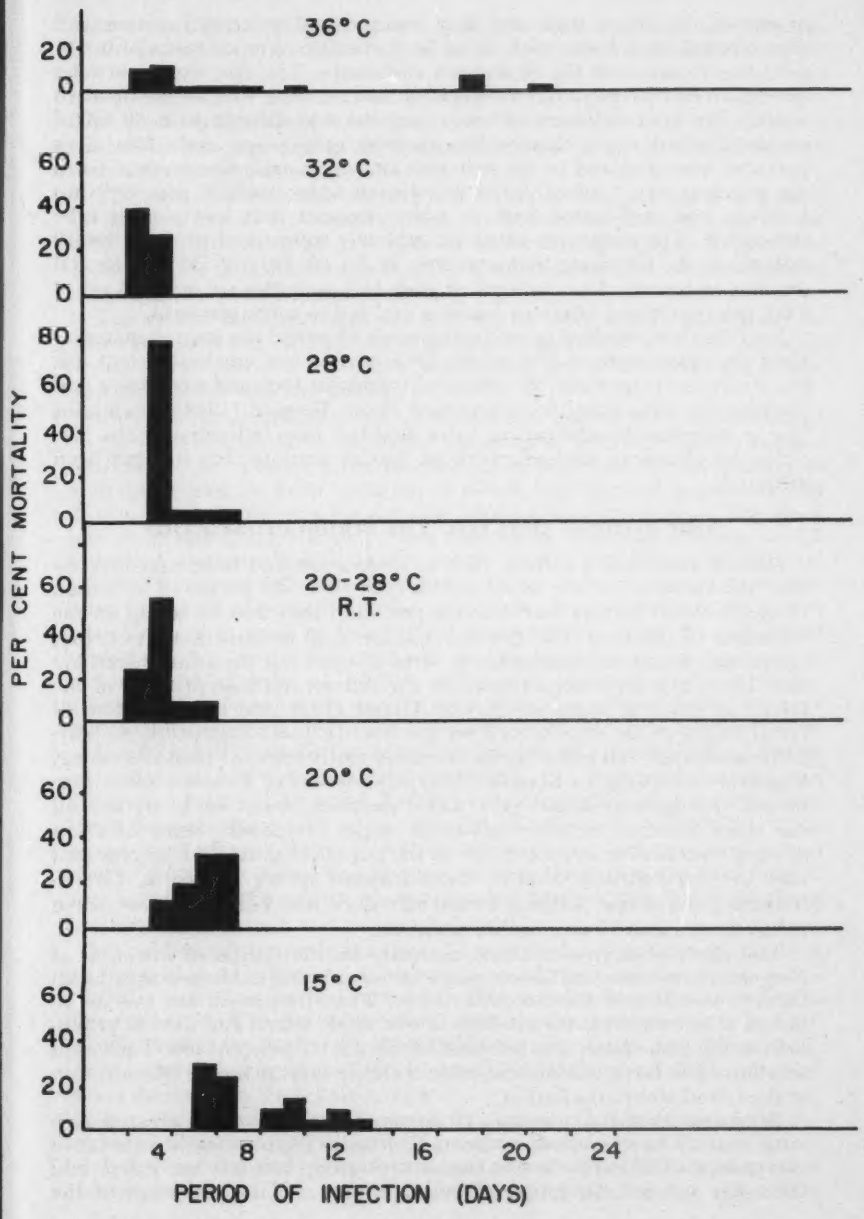

Fig. 5. Effect of temperature on the period of infection of *Bergoldia virulenta* n. sp. in *Pieris rapae* (L.).

in one of the above trials was first concentrated by centrifugation and then treated for 5 hours with 20 ml of a mixture of equal parts of 0.1 M sodium chloride and 0.1 M sodium carbonate. The free virus particles were purified by repeated centrifugation and washing with sterile distilled water. The final sediment of virus particles was diluted with 50 ml of sterile distilled water. Under the electron microscope, only free virus particles were observed in the sediment and no granule was present. As in the previous test, 3 ml of the virus solution were carefully pipetted into a sterile vial and sealed with a rubber stopper that had a glass tube through it. The vials were heated completely submerged in water for 10 minutes at the following temperatures: 55, 60, 65, 70, and 75° C. One vial was left unheated. The contents of each vial were diluted with 25 ml of a 0.2 per cent blood albumin solution and fed to cabbageworms.

No infections resulted from the ingestion of any of the treated material. Even the suspension of free virus particles that was not heated had lost its virulence. Apparently the chemical treatment required to dissolve and liberate the virus particles inactivated them. Bergold (1948*b*) maintains that a complete breakdown of virus bundles into individual virus particles, by chemical methods, without loss of activity, has not yet been achieved.

SOME FACTORS AFFECTING THE PERIOD OF INFECTION

Certain attenuating factors, such as desiccation and heat, may directly alter the virulence of the virus, and thereby affect the period of infection. However, other factors may vary the period of infection by acting on the resistance of the host. The general opinion held by most workers is that larvae and pupae are susceptible to virus diseases but the adult insects are not. There also have been reports of the differential susceptibility of the larvae in different stages of growth. Glaser (1928) has reported that all larval stages of the silkworm, *Bombyx mori* (L.), are susceptible to polyhedrosis disease, but older larvae are more easily infected than the young. However, according to Bergold (1943), the larvae of *Bombyx mori*, *Porthetria* (*Lymantria*) *dispar* (L.), and *Lymantria monacha* L. do not all die when infected in more advanced stages of growth. Some of them develop into adults, and others die in the pupal stage. In 1951, he reported that the polyhedrosis virus of the European spruce budworm, *Choristoneura fumiferana* (Clem.), frequently does not kill the larvae when fed to them about 10 days before pupation.

The effect of degree of larval maturity on the period of infection of *Bergoldia virulenta* was investigated by inoculating cabbageworms of all the five instars and the late fifth instar. The virus inoculum was maintained at a constant concentration of one larva, which had died of granulosis in the fifth instar, diluted with 50 ml of a 0.2 per cent blood albumin solution. The larva was macerated in a sterile mortar before the addition of the blood albumin solution.

In testing the first five instars, 20 larvae of each instar were treated with virus and 20 were used as controls. The control group was divided into two groups of 10 each. One of the control group was left untreated, and the other was fed the blood albumin solution. In the late stage of the

fifth instar, 28 larvae were treated with virus and 26 larvae were kept as controls. Eighteen of the 26 control larvae were untreated and eight were fed the blood albumin solution. All the different instars were not inoculated at the same time because of the lack of larvae of the proper age. There was undoubtedly some variation in environment at the different times but this was negligible because the conditions in the laboratory were rather uniform.

The period of infection for the first 3 instars ranged from 2 to 4 days; for the fourth and fifth instars, from 3 to 6 days; for the late stage of the fifth instar, from 4 to 26 days with 24 of the 26 deaths occurring in 4 to 13 days. Two of the larvae in this last group matured to adults. None of the control larvae died of granulosis.

The results indicated that all five instars were highly susceptible to granulosis and that the period of infection increased with the maturity of the larvae. Some of the larvae which were fed virus a few days before pupation developed into adults.

Since the susceptibility of the cabbageworm may depend on the dosage of the virus inoculum, larvae in the third instar were fed virus at various concentrations. A stock virus inoculum was prepared by macerating, in a sterile mortar, a fifth instar larva which had died of granulosis and diluting with 50 ml of a 0.2 per cent blood albumin solution. The stock inoculum was diluted with 0.2 per cent blood albumin solution to the following concentrations: 1:2; 1:20; 1:200; 1:2,000; 1:20,000; 1:200,000; and 1:2,000,000. Since sufficient third instar larvae were not available to perform the entire experiment at the same time, the study was made in two trials. The first trial included the concentrations from the undiluted stock inoculum to 1:2,000 dilution. In the second trial, the treatments included the dilution of 1:2,000, which was repeated, and the higher dilutions. Ten larvae were used in each test group. There were 20 larvae in the control groups and in the groups treated with the 1:2,000 solution.

The virus killed all the larvae up to a dilution of 1:2,000. At the 1:20,000 concentration, five larvae died of granulosis, two from other causes, and three emerged as adults; at 1:200,000, two larvae died of granulosis, one from another cause, and seven emerged as adults; at 1:2,000,000, three larvae died of granulosis, five from other causes and two emerged as adults. Thus the virus was apparently infectious even at dilutions of over 1:20,000. In the control groups there were two deaths from granulosis, two from other causes, and 16 became adults.

Fig. 4 shows graphically the effect of varied concentrations of the virus on the period of infection. As the dilution of the virus was increased to 1:2,000, there was a gradual increase in the period from infection to death. There was a shift in the mode from 3 days for the stock inoculum and the 1:2 dilution to 6 days for the 1:2,000 dilution. In the groups treated with suspensions ranging from 1:20,000 to 1:2,000,000, most of the infected larvae died within 8 to 22 days.

Since the period of infection of granulosis may possibly vary with the source of virus material, i.e., whether from a dead larva or from a live infected larva, the following study was initiated to investigate the possibility of such variations. The virus inocula were prepared from a fifth instar

larva which had died of granulosis 24 hours previously and from a fifth instar larva which was in the late stage of infection. The external surfaces of the infected larva were "disinfected" by immersing the larva in a tincture of merthiolate for about one minute. The merthiolate was washed off with several rinses of sterile distilled water. The larva was placed in a sterile dish and the digestive tract removed intact. The remainder of the larva, minus the digestive tract, was ground in a sterile mortar, and diluted with 50 ml of 0.2 per cent blood albumin solution. The dead larva was also ground in a sterile mortar and diluted with 50 ml of 0.2 per cent blood albumin solution. Each test was made on 15 larvae in their fourth instar and the control consisted of 10 larvae of the same age.

The results indicated that there was no difference in the period of infection for the two types of virus inocula tested. In both test groups, the period from infection to death was 3 to 5 days, with most of the larvae dying in 4 days. One of the control larvae died from causes other than granulosis.

In general, the period of infection of an insect virus disease varies with temperature. At high temperatures, the course of the disease is more rapid than at lower temperatures (Paillot 1924, Glaser 1928, Paillot 1943, Bergold 1943, Thompson and Steinhaus 1950). The period of infection of *Bergoldia virulenta* was studied under the following temperatures: 15, 20, 28, 32, and 36° C and at room temperature of 20 to 28° C. For the fixed temperature studies above 25° C, the larvae were reared in a chamber equipped with a thermostat which maintained the temperature within one to two degrees. A small fan was kept in constant operation in the chamber. A pan of water was placed in the chamber to reduce the drying of the larval food as much as possible. A refrigerator, the temperature of which could be regulated, was used to study the effect of temperatures below 25° C.

The virus inoculum consisted of the macerated contents of a dead fifth instar larva diluted with 50 ml of a 0.2 per cent blood albumin solution. The number of fourth instar larvae used in each trial varied with the number of larvae available. At 15° C, 20 larvae were fed the virus inoculum, 10 were fed the blood albumin solution, and 10 were untreated; at 20° C, 15 larvae were fed the virus, 10 the blood albumin solution, and 5 were untreated; at room temperature, 20 were fed the virus, 10 the blood albumin solution, and 10 were untreated; at 28° C, 15 were fed the virus, 10 the blood albumin solution, and 5 were untreated; at 32° C, 15 were fed the virus and 10 were untreated; at 36° C, the total of two trials was 30 larvae which were fed the virus inoculum, 20 which were fed the blood albumin solution, and 10 were untreated.

The results are presented in the form of a histogram (Fig. 5). None of the control larvae died from granulosis, but some died from other causes. There was a decrease in the period of infection with an increase in temperature up to 32° C. At 15° C most of the larvae died from 6 to 7 days after infection, while at 32° C they died in 3 to 4 days. All the treated larvae which were reared at temperatures up to 28° C died of granulosis. Some of the larvae apparently died from bacterial infections at 32 and 36° C. Surprisingly, the period of infection at 36° C increased rather than

decreased, and some of the treated larvae survived up to 21 days before dying. Moreover, some larvae apparently died from the high temperature rather than from granulosis because they formed abnormal prepupae which did not contain typical granules. Many of the control larvae at 36° C also formed such abnormal prepupae.

SUSCEPTIBILITY TO GRANULOSIS AT 36° C

Since the previous study indicated that at 36° C there was either an increased larval resistance to granulosis or a reduced virulence of the virus within the *P. rapae* larva, it might be asked if an infected larva would recover from granulosis when reared at a high temperature. This problem was investigated in the following tests. In the first test, the treatments included the effect of varied intervals of high temperature (36° C) on the survival of larvae infected with granulosis. Each larva was transferred from the high temperature to room temperature for pupation in order to avoid its developing into an abnormal prepupa. Even uninfected larvae formed abnormal prepupae at the high temperature. The relative humidity of the cabinet at 36° C was about 45 per cent. The treatments were as follows:

Ac—control group reared at room temperature..... 5 larvae
Ag—larvae fed virus, reared at room temperature..... 5 larvae
B—virus suspension dried for 24 hours at 36° C and fed to larvae reared at room temperature.....10 larvae
C—control group reared at 36° C.....10 larvae
D—larvae fed virus, reared 2 days at 36° C.....10 larvae
E—larvae fed virus, reared 4 days at 36° C.....15 larvae
F—larvae fed virus, reared 6 days at 36° C.....10 larvae

The larvae were in their fourth instar. The inoculum was prepared by macerating one larva which had died of granulosis in the fifth instar and diluting with 50 ml of 0.2 per cent blood albumin solution.

The results are given in Table 1. None of the controls died of granulosis, but the control group (treatment C, kept at 36° C) had three deaths, two of them apparently from an inability to produce normal pupae. All the larvae died of granulosis when reared at room temperature (treatments Ag and B), and when reared at 36° C for 2 days (treatment D). The death of all the larvae from granulosis in treatment B indicated that the virus was not inactivated by drying at 36° C for 24 hours. Since the food dipped in the virus inoculum was removed after 24 hours, there was no need to test the viability of the virus for longer periods of drying at the high temperature. In both treatments E and F, nearly half of the larvae matured to adults while the other half died from granulosis. It is highly probable that the adults in treatments E and F were infected by the virus as larvae, since all the larvae which were reared for only 2 days at 36° C died of granulosis. The results indicated that larvae of the imported cabbageworm could mature to adults when the infected larvae were reared for 4 or more days at 36° C and removed to lower temperatures just prior to pupation.

Since the above test indicated that the larvae could survive from granulosis when infected and reared for over 2 days at 36° C, the next question

Table 1. Survival of the imported cabbageworm to infection from **Bergoldia virulenta** n. sp. when reared at 36° C for various intervals of time

Treatments	Number Larvae Tested	Number Dead Larvae		Number Dead Pupae		Total Dead	Total Adults
		Granulosis	Others	Granulosis	Others	Granulosis	
Ac. Control 1	5	0	0	0	0	0	5*
Ag. Infected at room temperature	5	5	0	0	0	5	0
B. Infected with dried virus at room temperature	10	10	0	0	0	10	0
C. Control 2 at 36° C	10	0	1	0	2	0	7
D. Infected for 2 days at 36° C	10	10	0	0	0	10	0
E. Infected for 4 days at 36° C	15	3	0	6	0	9	6
F. Infected for 6 days at 36° C	10	1	0	3	1	4	5

*One normal hibernating pupa.

which arose was this: would larvae infected at room temperature also recover when they were removed to higher temperatures? Three tests were conducted to answer this question. In the first test the treatments were as follows:

A—control, fed blood albumin solution at 36° C..... 5 larvae
B—control, untreated, reared at 36° C.....10 larvae
C—control, untreated, reared at room temperature.....10 larvae
D—infected and reared at 36° C.....10 larvae
E—infected and reared at room temperature for 2 days then to 36° C.....10 larvae
F—infected and reared at room temperature for 3 days then to 36° C.....10 larvae
G—infected and reared at room temperature for 4 days then to 36° C.....10 larvae
H—infected and reared at room temperature.....10 larvae

None of the treated larvae survived. In treatments E, F, and G, kept at room temperature for 2, 3, and 4 days after infection before being transferred to 36° C, the larvae died in 3 to 5 days. The same period of 3 to 5 days occurred in treatment H that was maintained at room temperature throughout. This comparable period of infection indicated that there was no decreased virulence of the virus within the host or no increased larval resistance at the high temperature. However, the heat treatment had a slight effect on treatment D, in which the period of infection was spread out over a range of 4 to 10 days, although most of the deaths occurred on the sixth day. Only one of the control larvae reared at 36° C reached adulthood. The remainder died because they were not transferred to room temperature sufficiently early for them to pupate normally.

Since the high virulence of the virus and the presence of secondarily pathogenic bacteria might have caused the failure of the above test, a second experiment was conducted with an attenuated form of the virus. The virus was attenuated by drying a smear of virus suspension on sterile glass slides and storing for 74 days in the dark at room temperature. The drying process also destroyed most of the non-spore forming bacteria. The

virus inoculum was prepared by scraping off the dried virus smears from five slides into 25 ml of a 0.2 per cent blood albumin solution. The treatments were as follows:

C—control fed blood albumin solution at 36° C.
A—infected and reared at 36° C.
B—infected and reared at room temperature for 2 days then to 36° C.
D—infected and reared at room temperature for 3 days then to 36° C.
E—infected and reared at room temperature for 5 days then to 36° C.
F—infected and reared at room temperature.

There were 10 fourth instar larvae in each test group. The procedure was the same as in the first test. All larvae just prior to pupation were transferred to room temperature.

The results are given in Table 2. As the period of infection in treatment F was 8 to 10 days, with one larva dying over a month later as a pupa, the virus inoculum of this test was evidently much less virulent than that of the first test. At least one adult emerged from each treatment except treatment F. In treatment A, that maintained at 36° C, half of the larvae matured successfully. In treatment B, there were eight dead pupae, which died from granulosis, and two became adults. Treatments D and E each had one larva which reached adulthood. In treatment D, however, five of the larvae did not die from granulosis since samples of their blood, when examined under the electron microscope, did not contain any typical granules. The results of this test indicated that the longer a larva was reared in an infected condition at room temperature, the less the likelihood of its recovery when transferred to 36° C. Apparently at an advanced stage of infection, the heat treatment could not prevent the larvae from dying.

Table 2. Survival of the imported cabbageworm from granulosis when infected at room temperature and transferred to 36° C after various intervals of time

Treatments	Number Dead Larvae		Number Dead Pupae		Total Dead	Total Dead	Total
	Granulosis	Others	Granulosis	Others	Granulosis	Others	Adults
C. Control, blood albumin at 36° C	0	1	0	7	0	8	2
A. Infected at 36° C	0	0	4	1	4	1	5
B. Infected at room temperature 2 days	0	0	8	0	8	0	2
D. Infected at room temperature 3 days	2	5	2	0	4	5	1
E. Infected at room temperature 5 days	9	0	0	0	9	0	1
F. Infected at room temperature	9	0	1	0	10	0	0

The treatments of the third test were the same as of the second except that treatment F was omitted. The virus suspension was attenuated by heating it in a water bath maintained at 60 to 65° C for 10 minutes. After cooling to room temperature, 0.1 gm of blood albumin was added to the suspension.

Since none of the treated larvae survived, the virulence of the virus was not reduced sufficiently to enable the infected larvae to survive the granulosis infection when transferred to 36° C. However, the period of infection increased among larvae which were maintained longer at 36° C than among those which were in the high temperature for a shorter interval.

At times the symptoms of the infected larvae when reared at 36° C differed from those of larvae reared at room temperature. Some of the infected larvae turned pale green and died just as those at room temperature. Others, however, turned from a pale green to a yellowish color and appeared somewhat translucent. Their bodies were slightly bloated. Occasionally the feces were tinted with a yellow substance. In some of these larvae, the granules, when examined under the electron microscope, were not the same as those of *Bergoldia virulenta*. These larvae generally lived for a relatively long period before dying.

The above tests indicated that the likelihood of a larva surviving a granulosis infection depended mainly on the virulence of the pathogen and the stage of infection at which the heat treatment was applied. In *Colias philodice eurytheme*, Thompson and Steinhaus (1950) reported that within the temperature range (10 to 33° C) in which the alfalfa caterpillar was active, susceptibility to polyhedrosis was independent of temperature, although the incubation period of the disease fluctuated with temperature. They were not able to study the infection of the virus at temperatures above 33° C because the larvae were killed by bacteria.

Was the survival of infected *Pieris rapae* larvae at 36° C the result of an inability of the virus to multiply in the host, or of an increased cellular and humoral immunity which were brought into effect by the high metabolic rate of the host? These interesting aspects of the problem were not investigated.

TRANSMISSION TO THE ALFALFA CATERPILLAR

Since the alfalfa caterpillar, *Colias philodice eurytheme*, belongs to the same family Pieridae as the imported cabbageworm, the possibility of transmission of *Bergoldia virulenta* to the alfalfa caterpillar was investigated. In two preliminary tests, the alfalfa caterpillars were fed virus inoculum prepared from a fifth instar cabbageworm which had died from granulosis. All the treated alfalfa caterpillars died. They contained many small rods and granule-like particles, which, under the electron microscope, were ellipsoidal in outline and varied greatly in size. The ellipsoidal shape of the particles distinguished them from the granules of *Bergoldia virulenta*.

Since the death of the alfalfa caterpillars could have been caused by bacteria present in the virus inoculum, two further tests were conducted in which infected tissues from live cabbageworms in the late stage of granulosis were fed to the alfalfa caterpillars. In both trials, the virus inoculum was prepared from an infected fifth instar cabbageworm whose external surfaces were "disinfected" in merthiolate for 3 minutes and the merthiolate washed off with 10 rinses of sterile distilled water. The larva was dissected with sterilized instruments and about a fourth of its fat,

muscles, and skin removed without rupturing the gut. The tissues were ground in a sterile mortar and diluted with 50 ml of a 0.2 per cent blood albumin solution. A sample of the inoculum when examined under the light microscope contained many granules and no signs of bacteria.

The treatments consisted of 10 *Colias* larvae which were fed the virus inoculum, five untreated larvae, and five larvae which were fed the blood albumin solution. The virus inoculum was found to be highly infectious to five cabbageworms which were fed the virus. Among the 10 alfalfa caterpillars which were fed the virus inoculum, there were two deaths, one from bacteria and the other from an unknown cause. The remaining eight larvae reached adulthood. Four of the untreated control larvae died, two from polyhedrosis and two from bacteria. One of the control larvae which was fed blood albumin died from polyhedrosis. The remaining five control larvae developed into adults.

In the second test, the virus inoculum was also found to be highly infectious to cabbageworms. Out of the 15 alfalfa caterpillars which were fed the virus inoculum, nine of them died, all showing some granular particles and small bacteria. In the control group of 15 larvae, there were four deaths. Three of the dead larvae contained granular particles and small bacteria. One larva died from polyhedrosis.

Although the performance of the control groups in the above trials was not very satisfactory, the results obtained indicated a probability that the granulosis virus of the cabbageworm might not be infectious to the alfalfa caterpillar.

A third test was conducted to determine whether the body contents of alfalfa caterpillars which had died with granular particles present in them would be infectious to the cabbageworm. The remains of two of the larvae which had died in the above second trial were macerated separately and each diluted with 100 ml of 0.2 per cent blood albumin solution. Both inocula contained many granular particles and small bacterial rods. Each inoculum was fed to a group of 15 cabbageworms. In the control group, 10 cabbageworms were fed the blood albumin solution and five were untreated. At the conclusion of the trial, there were no deaths among the 30 cabbageworms which were fed the body contents of the dead caterpillars; all pupated normally. One of the control larvae died from bacteria.

The results indicated that the granular particles found in the dead alfalfa caterpillars were not infectious to the imported cabbageworm. As pointed out earlier, the granular particles found in the alfalfa caterpillar differ in size and shape from the granules of *Bergoldia virulenta*.

BACTERIA ASSOCIATED WITH GRANULOSIS

Since bacteria are often found in larvae which die of granulosis, the question arises whether these bacteria are "true" pathogens or "opportunists."[8] In some instances in which the imported cabbageworm died in a very short time, such as 2 to 4 days, there may have been a mixed infection of bacteria and virus. Sometimes the bacteria were present in

[8] Steinhaus (1949*a*) defines "opportunists" as those microorganisms which live in constant association with the host, such as those in the alimentary tract, and which, under certain conditions, such as when the resistance of the hosts is lowered invade the more susceptible parts of the insect's body.

such large numbers that they apparently killed the cabbageworm before the virus did. Cabbageworms, which died from a mixed infection of virus and bacteria, were usually contracted, greenish in color and had a firm integument, as contrasted to the relaxed form, yellowish-white color, and delicate integument found in a typical case of granulosis.

A study was undertaken to determine whether the bacteria associated with *Bergoldia virulenta* were true pathogens. From a recently dead larva, whose blood contained many granules and small bacteria, a sample of the blood was streaked on a plate of plain nutrient agar. Two types of bacterial colonies were isolated onto agar slants. No attempt was made to identify these bacteria, other than to note some of their general physical characteristics. The first bacterial colony was small, elevated, circular in outline, and had a smooth surface. It was creamy white in color with a faint indication of red. It was composed of small gram-negative rods which were about 0.5 by 1.3 microns. The second bacterium formed very small pin-point colonies, white in color and with a smooth surface and margin. Its colonies grew very slowly in nutrient agar. The bacterium was a gram-positive coccus found usually in pairs but sometimes in chains. Its outline was broadly ovoid, and the long diameter measured approximately 0.7 micron.

A suspension of each bacterium was fed to a group of 18 fourth instar cabbageworms. The control group contained 10 larvae which were fed blood albumin solution, and seven larvae which were untreated. Two of the 18 larvae which were fed the gram-negative small rods died on the fourteenth and sixteenth days after infection. Their bodies contained a very large number of small to medium-sized bacteria. There was no indication of a virus infection. None of the 18 larvae which were fed the gram-positive coccus died of bacterial infection, but one died of polyhedrosis in the pupal stage. All the remaining larvae of both groups matured to adults. In the control, one larva died from bacterial infection and the remainder reached adulthood.

The bacteria which were isolated in this study apparently were "opportunists" rather than true pathogens. However, it may be that neither of these two species was responsible for the death of the larva since the isolation of the true pathogen might not be possible with plain nutrient agar.

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SUMMARY

A granulosis virus, which infects the imported cabbageworm, *Pieris rapae* (L.), has been described and named *Bergoldia virulenta*, n. sp. This virus has been found infecting *Pieris rapae* in California, Colorado, and Hawaii. The average size of the granules is approximately 0.2 by 0.3 microns. Most of the free virus particles are 41 to 50 millimicrons by 291 to 300 millimicrons in size. The external symptoms of granulosis in *Pieris rapae* resemble those of a polyhedrosis. The infected larva gradually turns pale and dies in a wilted condition. The fat and hypodermis are the only tissues with distinct signs of pathology.

Bergoldia virulenta is capable of withstanding desiccation and freezing for several months. Its thermal inactivation point is between 70 and 75° C for 10 minutes. The thermal inactivation time lies between 20 and 30 minutes at 70° C.

The period of granulosis infection in *Pieris rapae* varies with the age of the larva, the concentration and virulence of the virus inoculum, the temperature at which the larva is reared, and the presence of secondary pathogens. There is apparently no difference in the period of infection if the virus is obtained from a dead larva or from a living larva in the late stage of infection.

At a high temperature (36° C), there is an increase in the length of the period of infection to granulosis. When larvae are infected with granulosis at 36° C and reared at this temperature until just prior to pupation, some of them may survive and mature to adults. Some fourth instar larvae, which are infected at room temperature and transferred to 36° C after 2 to 5 days may mature to adulthood.

The bacteria which were commonly associated with granulosis infection during this study appear to have been "opportunists" rather than true pathogens.

All attempts have failed to transmit *Bergoldia virulenta* to several lepidopterous hosts known to be susceptible to a granulosis infection. The granulosis viruses from these hosts, in turn, are not infectious to *Pieris rapae*. Attempts to transmit *Bergoldia virulenta* to the alfalfa caterpillar, *Colias philodice eurytheme* Boisd., have failed.

LITERATURE CITED

Abrams, L. 1940. Illustrated flora of the Pacific States. vol. 1. 538 pp. Stanford Univ. Press, Stanford Univ., Calif.

Bailey, L. H. 1949. Manual of cultivated plants. rev. ed. 1116 pp. Macmillan Co., New York.

Bergold, G. 1943. Über Polyederkrankheiten bei Insekten. Biol. Zentr., 63:1-55.

Bergold, G. 1948*a*. Über die Kapselvirus-Krankheit. Z. f. Naturforsch., 3b:338-342.

Bergold, G. 1948*b*. Bündelförmige Ordnung von Polyederviren. Z. f. Naturforsch., 3b:25-26.

Bergold, G. 1950. The multiplication of insect viruses as organisms. Can. J. Res., E, 28:5-11.

Bergold, G. 1951. The polyhedral disease of the spruce budworm, *Choristoneura fumiferana* (Clem.) (Lepidoptera: Tortricidae). Can. J. Zool., 29:17-23.

Brown, F. M. 1930. Bacterial wilt disease. J. Econ. Entomol., 23:145-146.

Forbes, S. A. 1886. Studies on the contagious diseases of insects. Bull. Illinois State Lab. Natural History, I., 2:257-321.

Glaser, R. W. 1928. Virus diseases of insects. *In* Rivers, T. M., Filterable viruses. Chap. 8, pp. 279-332. Williams & Wilkins Co., Baltimore.

Glaser, R. W., and **C. W. Lacaillade.** 1934. Relation of the virus and the inclusion bodies of silkworm "jaundice." Amer. J. Hyg., 20:454-464.

Holdaway, F. G., and **E. Lucas.** 1941. Biological control of cabbage worm. Rept. Hawaii Agr. Expt. Sta. 1940, pp. 41-42.

Hughes, K. M. 1952. Development of the inclusion bodies of a granulosis virus. J. Bact., 64:375-380.

Hughes, K. M., and **C. G. Thompson.** 1951. A granulosis of the omnivorous looper, *Sabulodes caberata* Guenée. J. Infectious Diseases, 89:173-179.

Moss, J. E. 1933. The natural control of the cabbage caterpillars, *Pieris* spp. J. Anim. Ecol., 2:210-231.

Paillot, A. 1924. Sur une nouvelle maladie des chenilles de *Pieris brassicae* L. et sur les maladies du noyau chez les insectes. Compt. Rend. Acad. Sci., Paris, 179:1353-1356.

Paillot, A. 1926. Sur une nouvelle maladie du noyau ou grasserie des chenilles de *Pieris brassicae* et un nouveau groupe de micro-organismes parasites. Compt. Rend. Acad. Sci., Paris, 182:180-182.

Paillot, A. 1935. Nouvel ultravirus parasite d'*Agrotis segetum* provoquant une prolifération des tissues infectés. Compt. Rend. Acad. Sci., Paris, 201:1062-1064.

Paillot, A. 1936. Contribution à l'étude des maladies à ultravirus des insectes. Ann. Épiphyt. Phytogénét., 2:341-379.

Paillot, A. 1937. Nouveau type de pseudo-grasserie observé chez les chenilles d'*Euxoa segetum*. Compt. Rend. Acad. Sci., Paris, 205:1264-1266.

Paillot, A. 1943. Ultravirus des insectes. *In* Les Ultravirus des maladies animales. (Under the direction of C. Levaditi, P. Lepine, and J. Verge) Librarie Maloine, Paris, pp. 1177-1191.

Pospelov, V. P., and **E. S. Noreiko.** 1929. Wilt disease (Polyederkrankheit) of caterpillars and the yeast, *Debaryomyces tyrocola* Kon., as its virus. Izv. Prikl. Ent., 4:167-183. (See Rev. Appl. Entomol., A, 18:130.)

Richards, O. W. 1940. The biology of the small white butterfly (*Pieris rapae*), with special reference to the factors controlling its abundance. J. Anim. Ecol., 9:243-288.

Romeis, B. 1948. Mikroskopische technik. 15th revised ed. 695 pp. Leibniz Verlag, Munich.

Steinhaus, E. A. 1946. Insect microbiology. 763 pp. Comstock Publ. Co., Inc., Ithaca, N. Y.

Steinhaus, E. A. 1947. A new disease of the variegated cutworm, *Peridroma margaritosa* (Haw.). Science, 106:323.

Steinhaus, E. A. 1949*a*. Principles of insect pathology. 757 pp. McGraw-Hill Book Co., Inc., New York.

Steinhaus, E. A. 1949*b*. Nomenclature and classification of insect viruses. Bacteriol. Rev., 13:203-223.

Steinhaus, E. A., K. M. Hughes, and **H. B. Wasser.** 1949. Demonstration of the granulosis virus of the variegated cutworm. J. Bact., 57:219-224.

Steinhaus, E. A., and **C. G. Thompson.** 1949. Granulosis disease in the buckeye caterpillar, *Junonia coenia* Hübner. Science, 110:276-278.

Sweetman, H. L. 1936. The biological control of insects. 461 pp. Comstock Publ. Co., Inc., Ithaca, N. Y.

Thompson, C. G. 1951. A granulosis of the imported cabbageworm. J. Econ. Entomol., 44:255.

Thompson, C. G., and **E. A. Steinhaus.** 1950. Further tests using a polyhedrosis virus to control the alfalfa caterpillar. Hilgardia, 19:411-445.

Wasser, H. B., and **E. A. Steinhaus.** 1951. Isolation of a virus causing granulosis in the red-banded leaf roller. Virginia J. Sci., 2:91-93.

White, G. F. 1917. Sacbrood. U.S.D.A. Bull. 431, 54 pp.

Wilson, H. F., R. C. Pickett, and **L. G. Gentner.** 1919. The common cabbage worm in Wisconsin. (*Pontia rapae* Linn.). Wisc. Agr. Expt. Sta. Res. Bull. 45, 46 pp.

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Editor Emeritus
O. H. SWEZEY

Editor
R. H. VAN ZWALUWENBURG

Correspondence concerning copies of the "PROCEEDINGS" should be addressed to the Secretary, Hawaiian Entomological Society, 1527 Keeaumoku St., Honolulu 14, Hawaii.